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Farmland Industries, Inc., Phosphate Mine Hardee County, Florida. Supplemental Information Document. Volume 1

(U.S.) Environmental Protection Agency
Atlanta, GA

May 81

U.S. Department of Commerce
National Technical Information Service
NTIS

United States
Environmental Protection
Agency

Region 4
345 Courtland Street NE
Atlanta, Ga. 30365

EPA 904/9-81-072A
May 1981

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EPA

Environmental Impact Statement

Draft

Farmland Industries, Inc.
Phosphate Mine
Hardee County, Florida

Supplemental Information Document

Volume 1

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Farmland Industries, Inc. has proposed an open pit phosphate mine and beneficiation plant on a 7810-acre site in west central Hardee County, Florida. Mining and processing will involve 5280 acres, all of which will be reclaimed, and will produce 2 million tons of phosphate rock per year for 20 years. The EIS examines alternatives, impacts and mitigative measures related to air, geology, radiation, groundwater, surface water, ecology and other natural and cultural systems.

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IV
345 COURTLAND STREET
ATLANTA, GEORGIA 30365

May 29, 1981

REF: 4SA-EIS

TO: ALL INTERESTED GOVERNMENTAL AGENCIES, PUBLIC GROUPS, AND CONCERNED INDIVIDUALS.

The Draft Environmental Impact Statement for the Farmland Industries Phosphate Mine and Beneficiation Plant is enclosed for your review. This document has been prepared pursuant to Section 102(2)(c) of the National Environmental Policy Act (NEPA) (Public Law 91-190) and applicable EPA regulations at 40 CFR Part 6.9. A Supplemental Information Document (in two volumes) has also been prepared which contains the supporting data related to the EIS. While the Draft EIS is a complete document, much of the technical detail has been presented in the Supplemental Information Document (SID) to reduce the length of the DEIS, to make the DEIS more analytical than encyclopedic, and to make the DEIS more understandable to the non-technical public. The Draft EIS and the SID may be reviewed at the following locations:

Lakeland Public Library, Lakeland, Florida
Bartow Public Library, Bartow, Florida
Ausley Memorial Library, Wauchula, Florida
DeSoto County Public Library, Arcadia, Florida
Selby Public Library, Sarasota, Florida
Manatee County Library System, Bradenton, Florida
Tampa-Hillsborough County Public Library,
    Tampa, Florida
Punta Gorda Public Library, Punta Gorda, Florida

A public hearing to discuss this project has been scheduled for July 14, 1981, at 7:00 p.m. in the Hardee County Agricultural and Civic Center, located at Altman Road and Stenstrom Road in Wauchula, Florida. Persons may begin to register at 6:30 p.m.

Persons wishing to make comments should attend and speak at the hearing. A verbatim transcript will be made of this public hearing. The hearing chairman may request that lengthy or technically complex statements be summarized and that, to ensure accuracy of the record, such statements be submitted in writing to:

Ms. A. Jean Tolman
EIS Project Officer
Environmental Protection Agency
Region IV
345 Courtland Street, N.E.
Atlanta, Georgia 30365

The hearing record will remain open and additional written comments may be submitted through July 28, 1981. Such additional comments will be considered as if they had been presented at the public hearing.

Recipients of this document should be aware that EPA will not reprint the material contained in the DEIS for the Final EIS. The Final EIS will consist of the Agency's statement of findings, any pertinent additional information or evaluations developed since publication of the Draft EIS, comments on the project and the Agency responses and the transcript of the public hearing.

Please bring this notice to the attention of all persons who may be interested in this matter.

Sincerely yours,

Rebecca W. Hanmer

Rebecca W. Hanmer
Regional Administrator

Enclosure: DEIS

DRAFT
ENVIRONMENTAL IMPACT STATEMENT

SUPPLEMENTAL INFORMATION DOCUMENT
VOLUME 1

Farmland Industries, Inc.
Phosphate Mine
Hardee County, Florida

May, 1981

Prepared for: U.S. Environmental Protection Agency
Region IV
345 Courtland Street, N.E.
Atlanta, Georgia 30365

Prepared by: Woodward-Clyde Consultants
Environmental Systems Division
1373 Broad Street
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1.0
INTRODUCTION

Farmland Industries, Inc. (Farmland) is a regional manufacturing, distribution, and marketing cooperative which provides a variety of services to some 1/2 million midwestern U.S. farm and ranch family member-owners. One of the primary services of the cooperative is the manufacture and distribution of fertilizers to its member-owners.

Farmland currently manufactures phosphate fertilizers in an existing facility at Green Bay, Florida. The rock raw material for this facility historically has been and currently is being bought from other mining companies in central Florida. During the history of the Green Bay facility, there have been times when Farmland has been unable to secure sufficient raw materials to operate this plant at its capacity and therefore has been unable to supply the necessary fertilizer to its member-owners. This has been particularly true during periods when heavy export demand has drained off both rock and fertilizer supplies from the domestic market. In order to prevent this situation from recurring, Farmland has proposed to construct and operate a 2 million ton per year wet phosphate rock mine in Hardee County, Florida, near the Town of Ona (Figure 1-1). The mine development will result in the disturbance of about 5000 acres of the 7800 acre tract which comprises Farmland's Hardee County reserve. During the 20+ year life of the mine, all of the rock mined from the tract will be shipped to existing fertilizer plants for conversion to finished fertilizer, with approximately 50 percent of the tonnage going to Farmland's existing Green Bay facility.

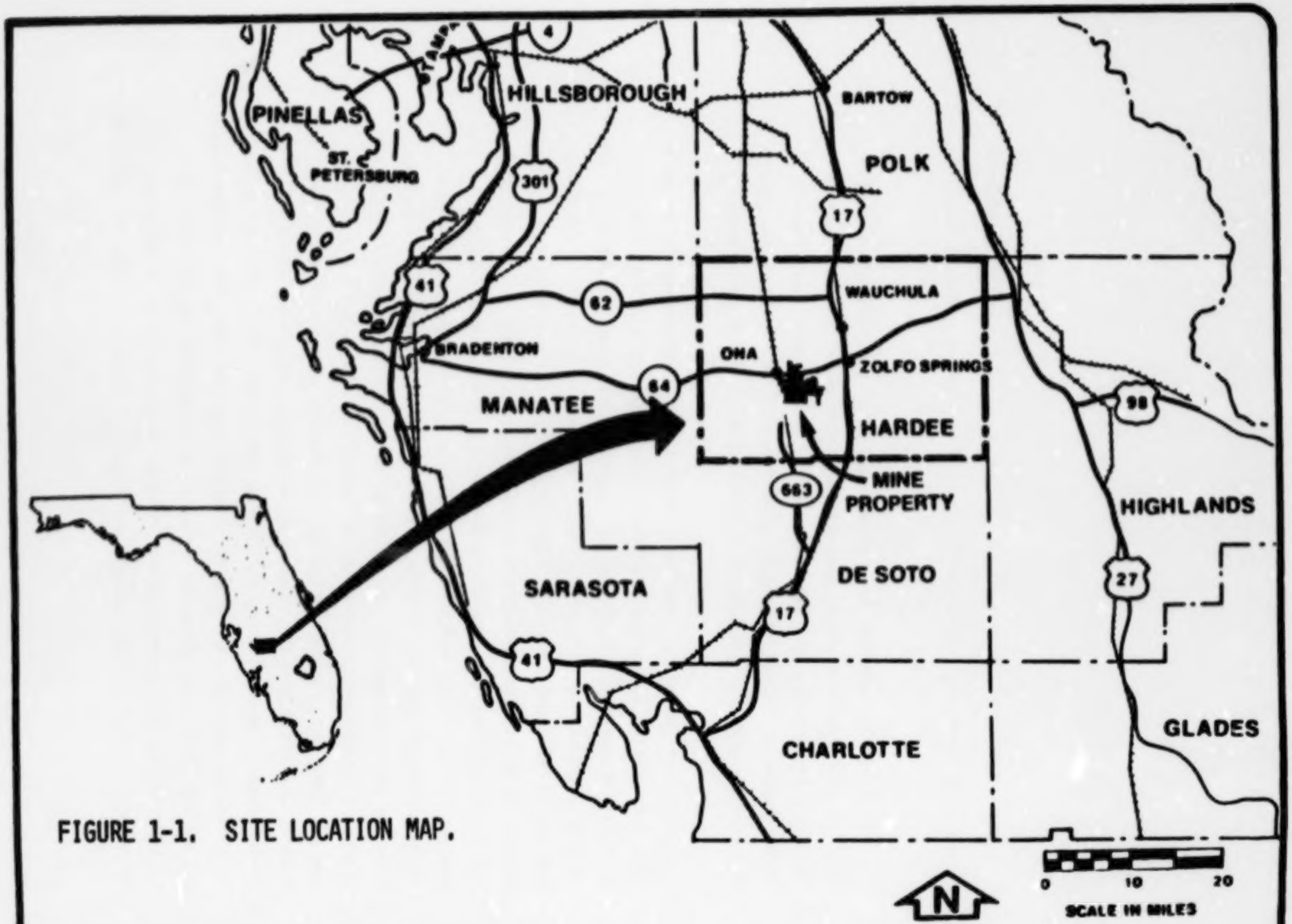

4
PINELLAS
ST. PETERSBURG
HILLSBOROUGH
301
BARTOW
POLK
17
41
62
WAUCHULA
BRADENTON
ONA
ZOLFO SPRINGS
64
MANATEE
HARDEE
98
663
MINE PROPERTY
HIGHLANDS
DE SOTO
SARASOTA
27
17
41
GLADES
CHARLOTTE
N
0
10
20
SCALE IN MILES

FIGURE 1-1. SITE LOCATION MAP.

SOURCE: FARMLAND INDUSTRIES, INC., DRI, JUNE 1979

This Supplemental Information Document (SID) has been prepared by Woodward-Clyde Consultants (WCC) as part of the supporting technical data and evaluations related to the U.S. EPA's EIS for the Farmland project. This information has been compiled in the form of an SID to reduce the length of the EIS, make the EIS more analytical than encyclopedic, highlight the most significant environmental concerns, and make the EIS more understandable to the non-technical public.

2.0
THE PROPOSED ACTION

2.1 DRAGLINE MINING OPERATION

2.1.1 DEPOSIT GEOLOGY

The ore body on Farmland's Hardee County tract is comprised of phosphatic pebble, sand, and clay of the Hawthorn Formation deposited from shallow seas that covered much of Florida during the Miocene epoch--about 15 million years ago. The ore (matrix) is quite variable in composition and is irregularly distributed over the property, both in quantity and quality. These irregularities are typical for phosphorite ore bodies in Hardee County. The overburden, which is composed primarily of sand and clay zones, is overlain by a thin layer of topsoil. The average overburden thickness for the property is 20.5 feet.

In comparison to the phosphate ore being mined in Polk and Hillsborough Counties, Farmland's ore is of lower grade and has finer sized particles. The average thickness of the mineable ore is 20.5 feet. As shown in Figure 2-1, the ore is comprised of approximately 20 percent phosphate rock product and 80 percent waste materials. The phosphate mineral is collophane, a calcium magnesium fluorapatite that contains small amounts of other minerals. Both the product and waste clay content of the ore compare favorably with other ore bodies in the Southern District. The material underlying the ore zone is composed of either bed clay or limestone, as shown in Figure 2-2. The ore zone base

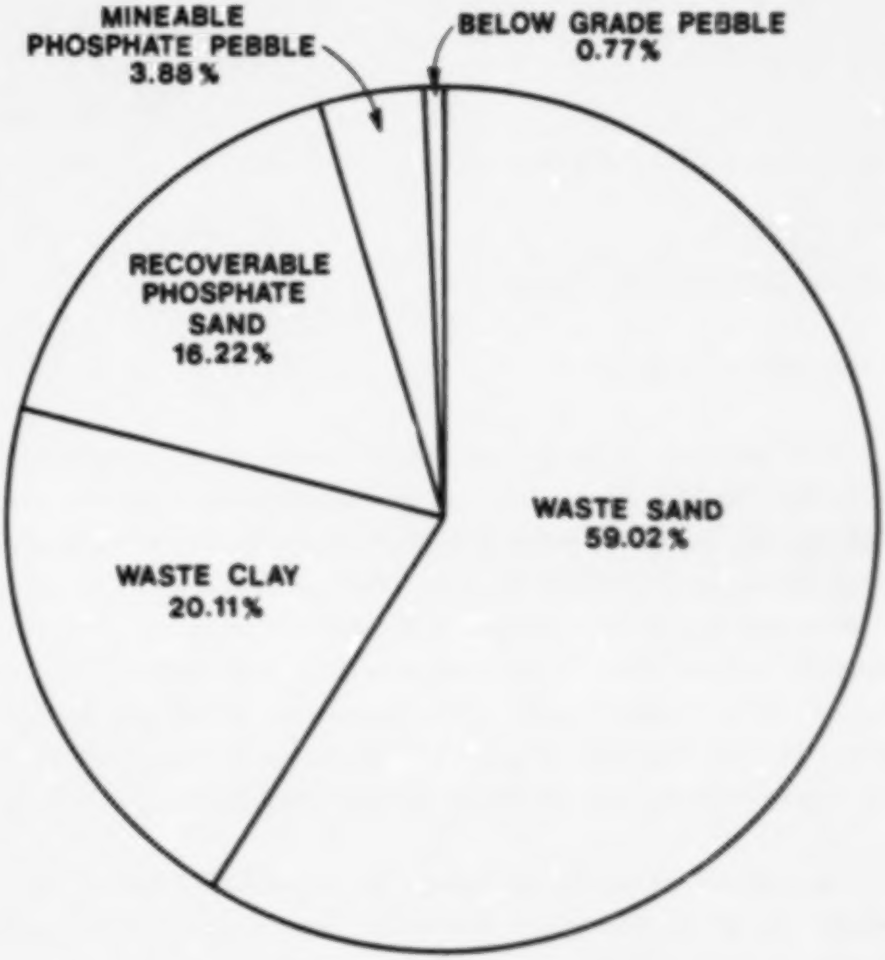


FIGURE 2-1. PHYSICAL COMPOSITION OF THE PHOSPHATE ORE.

SOURCE: FARMLAND INDUSTRIES, INC., HARDEE COUNTY MASTER PLAN, JUNE 1979

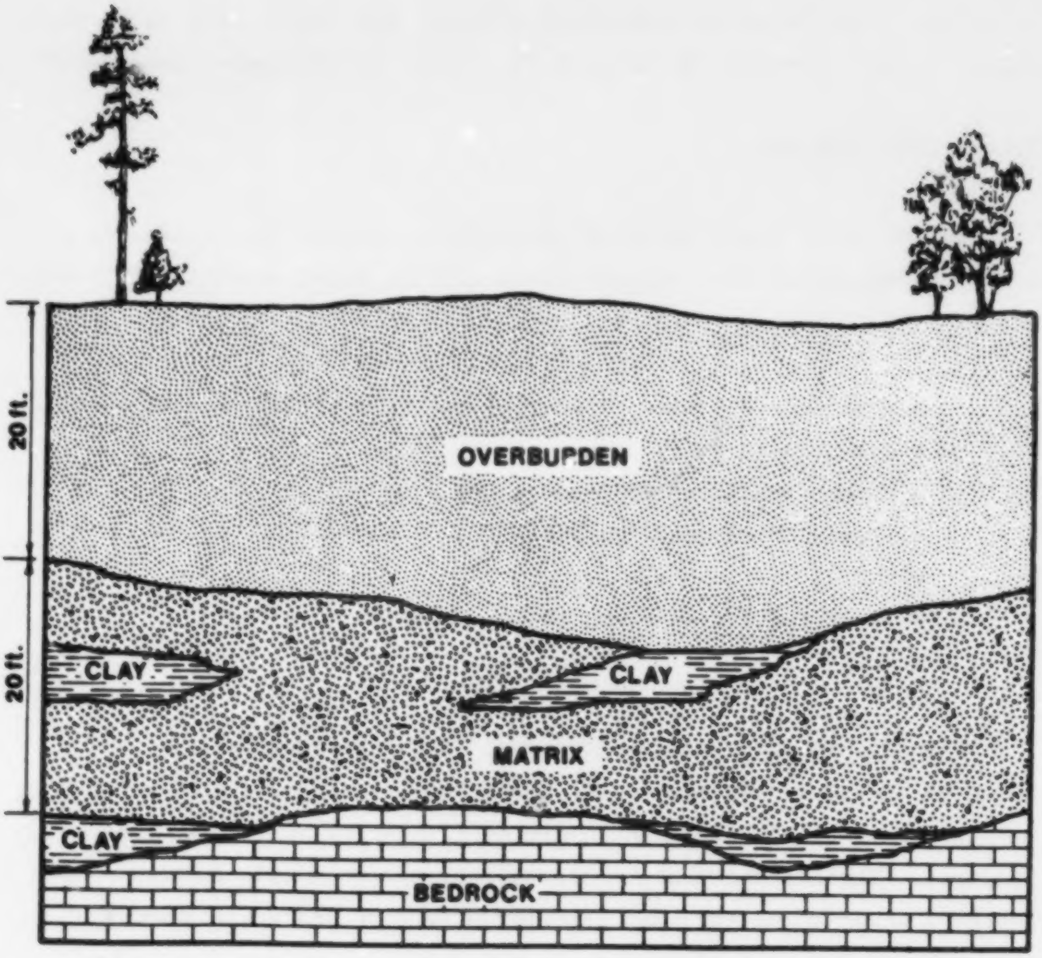

20 ft.
20 ft.
OVERBURDEN
CLAY
CLAY
MATRIX
CLAY
BEDROCK

FIGURE 2-2. TYPICAL CROSS-SECTION OF THE DEPOSIT.

SOURCE: FARMLAND INDUSTRIES, INC., HARDEE COUNTY MASTER PLAN, JUNE 1979

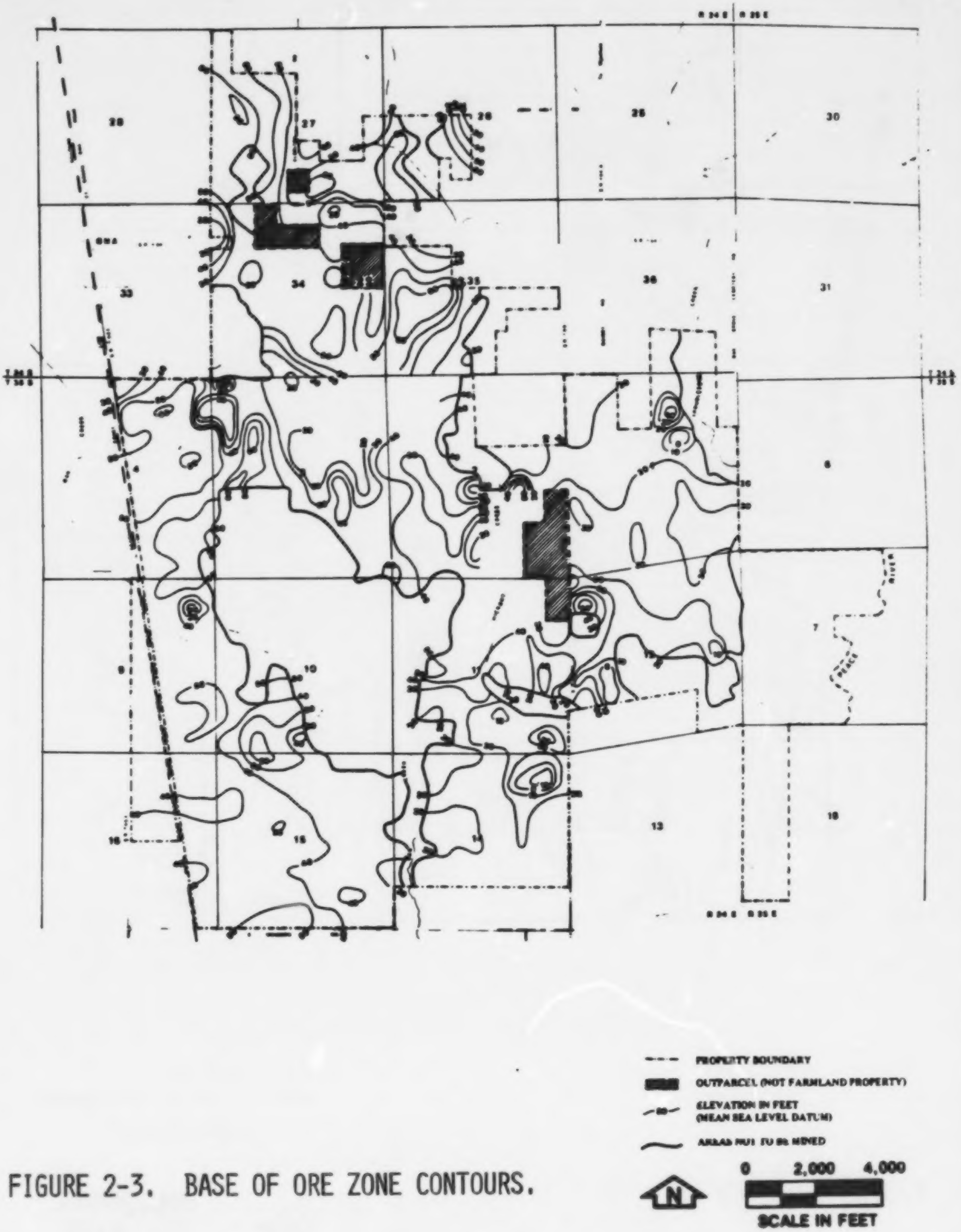
elevation is shown in Figure 2-3, and the top of the limestone in Figure 2-4. The total reserves considered mineable and recoverable by Farmland amount to approximately 39 million short tons of phosphate rock product.

2.1.2 LAND CLEARING

During the initial phase of the construction project, clearing of existing vegetation from natural soils will be required in the following areas:

- beneficiation site, including the rail yards and storage area
- dragline assembly area
- access roads and railroad spurs
- initial clay settling area
- initial mining area
- powerline and pipeline right-of-way
- ponds

Farmland plans to clear additional land only as that land is required by the mining operation. The existing vegetative cover will be maintained on all land for which mining or support activities are not imminent. The average that is cleared at any given time and the time interval prior to mining that clearing will take place will depend primarily on the type of land to be mined and the season of the year. The clearing of pine flatwoods-palmetto rangeland must be initiated several months prior to mining to allow complete removal of any woody material that might interfere with the mining process. In such areas it will also be desirable to clear sufficient land for 2-3 months mining prior to the onset of any rainy seasons. During the dry season, clearing will generally be only 10-20 acres in advance of the dragline unless the area to be mined is heavily vegetated. Improved pasture and other open areas will remain vegetated until they are mined. The average cleared acreage in front of the mining operation will be about 20 acres. Where necessary, vegetation cleared in advance of the mine will be


R 24 E | R 25 E
28
27
26
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35
36
31
T 33 S
T 34 S
6
7
10
9
15
16
13
18
PEACE RIVER
PROPERTY BOUNDARY
OUTPARCEL (NOT FARMLAND PROPERTY)
ELEVATION IN FEET
(MEAN SEA LEVEL DATUM)
AREAS NOT TO BE MINED
N
0 2,000 4,000
SCALE IN FEET

FIGURE 2-3. BASE OF ORE ZONE CONTOURS.

SOURCE: FARMLAND INDUSTRIES, INC., HARDEE COUNTY MASTER PLAN, JUNE 1979

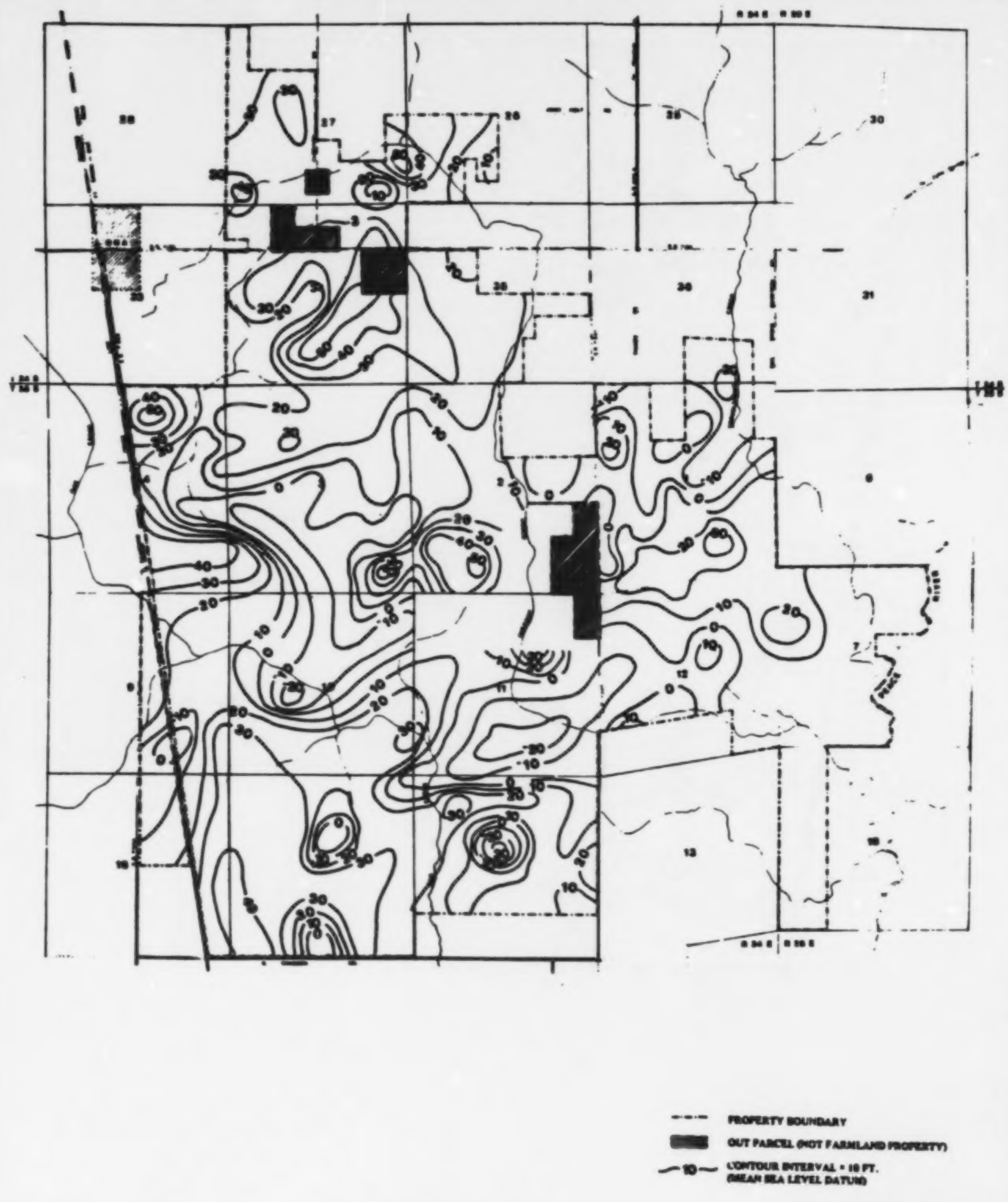

28
27
26
25
30
35
36
31
PROPERTY BOUNDARY
OUT PARCEL (NOT FARMLAND PROPERTY)
CONTOUR INTERVAL = 10 FT.
(MEAN SEA LEVEL DATUM)
0 2,000 4,000
SCALE IN FEET
N

FIGURE 2-4. TOP OF LIMESTONE CONTOURS.

SOURCE: FARMLAND INDUSTRIES, INC., HARDEE COUNTY MASTER PLAN, JUNE 1979

burned. Such open burning will be conducted according to the applicable rules and regulations (Florida Administrative Code, Chapter 17-5, Open Burning and Frost Protection Fires; and Chapter 51-2, Rural Open Burning). These rules specify that:

- Open burning must be conducted in a manner, under conditions, and within certain periods that will reduce or eliminate the deleterious effect of air pollution caused by open burning.
- Open burning may be conducted only between the hours of 9:00 a.m. and one hour before sunset, or upon direct permission of the Division of Forestry for other hours of the day.
- The size, moisture content, and composition of the refuse piles shall be such so as to minimize air pollution and insure that all burning will be completed within the allowable time period.

2.1.3 PRESERVED AREAS

Preserved areas (shown in Figure 2-5) account for 2530 acres, or approximately one-third of the mine site. These preserved areas fall into two categories--those excluded from disturbance due to economic mineability considerations, and those excluded from disturbance due to environmental sensitivity. Although environmentally sensitive areas preserved contained some phosphate ore, it was found that the deposits were not so extensive as to mandate recovery. By sacrificing some adjacent or interspersed deposits, the following environmentally valuable areas were excluded from disturbance:

- the hydric and mesic forests associated with the floodplain of the Peace River (Sections 7 and 18, T35S, R25E)
- the forested wetlands associated with the floodplain of Troublesome Creek (Section 1, T35S, R24E; and Section 36, T34S, R24E)

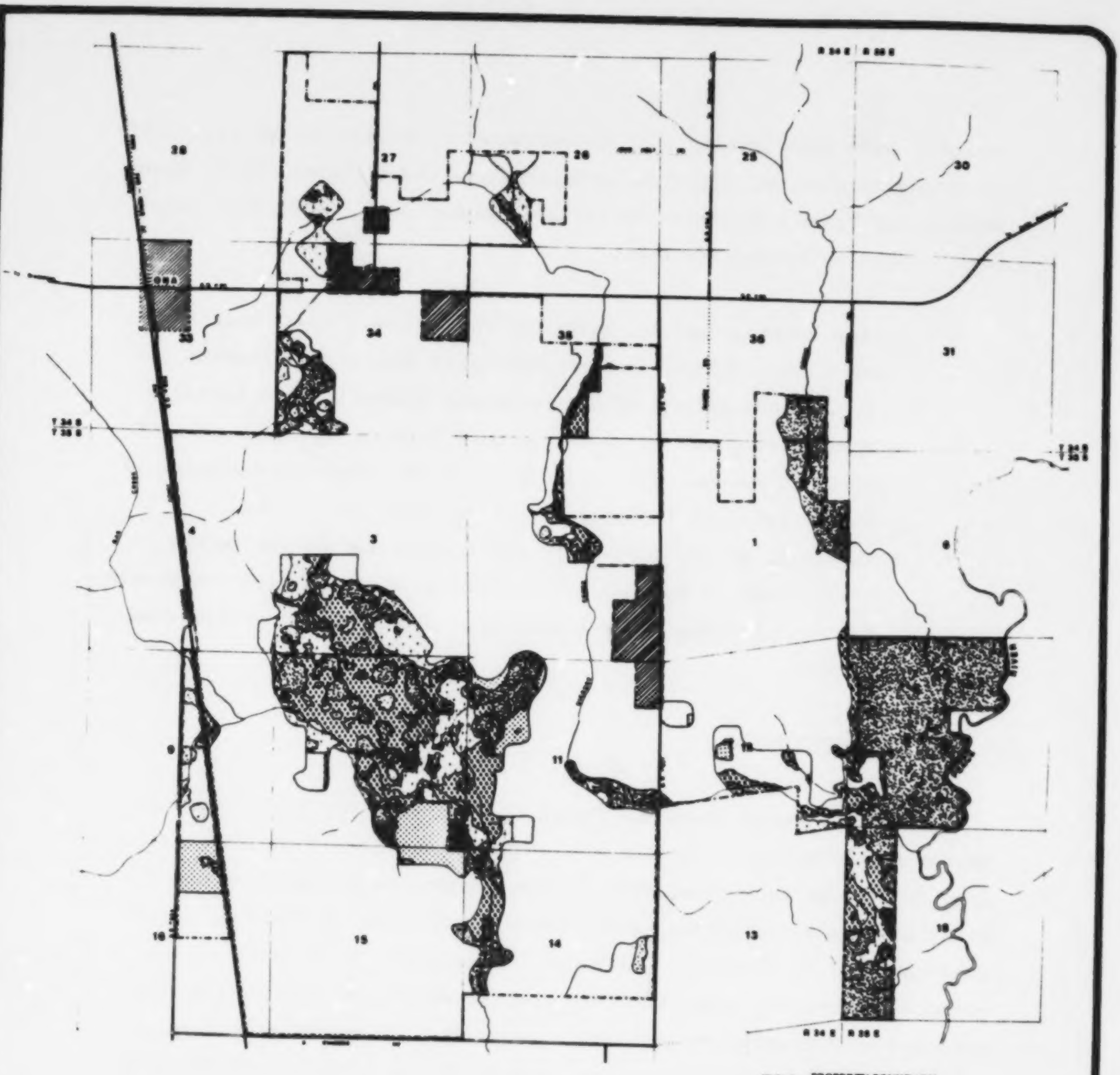

28
27
26
25
30
33
34
35
36
31
4
3
1
6
9
11
15
14
13
16
R 24 E R 25 E
T 34 S
T 35 S
PROPERTY BOUNDARY
OUT PARCEL (NOT FARMLAND PROPERTY)
FRESHWATER SWAMP
FRESHWATER MARSH
PINE FLATWOODS PALMETTO RANGE
UPLAND FOREST
IMPROVED PASTURE
CITRUS
OTHER AGRICULTURE
N
0 2,000 4,000
SCALE IN FEET

FIGURE 2-5. EXISTING LAND USE OF PRESERVED AREAS ON THE MINE SITE.

SOURCE: FARMLAND INDUSTRIES, INC., HARDEE COUNTY MASTER PLAN, JUNE 1979

- the heterogeneous mixture of upland forests, forested wetlands, and freshwater marshes known as Oak Creek Islands (Sections 3, 10, 11, and 14, T35S, R24E)
- the forested wetlands area along a northern tributary to Oak Creek (Section 34, T34S, R24E)
- the forested segments along the lower reaches of Hickory Creek (Section 2 and 11, T35S, R24E)

All the preserved areas of environmental significance are currently under lease for use as cattle range. Farmland intends to maintain these leases unless they conflict with the mining operation. The Soil Conservation Service will be consulted to determine the cattle stocking rates that will not adversely affect the ecology of the areas.

2.1.4 MATRIX MINING

Other than the fact that Farmland proposes to initially mine with a single large dragline rather than two smaller units, their mining method is the same as that conventional to the Florida phosphate industry. Farmland has studied the viability and economics of using the single large dragline during the first 9 years and found it satisfactory for their production requirements. This dragline will have a bucket size of approximately 45 cubic yards. In year 10 a second dragline with about a 20-cubic-yard bucket will be added to supplement the larger unit. The mine layout will generally be as depicted in Figure 2-6. As can be seen in this figure, the dragline removes the overburden and casts it into the mined out pit. Next it excavates the matrix and places it into the slurry pit for transport to the beneficiation plant. As the mining progresses, the dragline and the slurry pit equipment are moved to new locations (the slurry pit and related equipment are advanced while the dragline strips overburden). Electrical power is supplied to the dragline and pit equipment by portable electric cables.

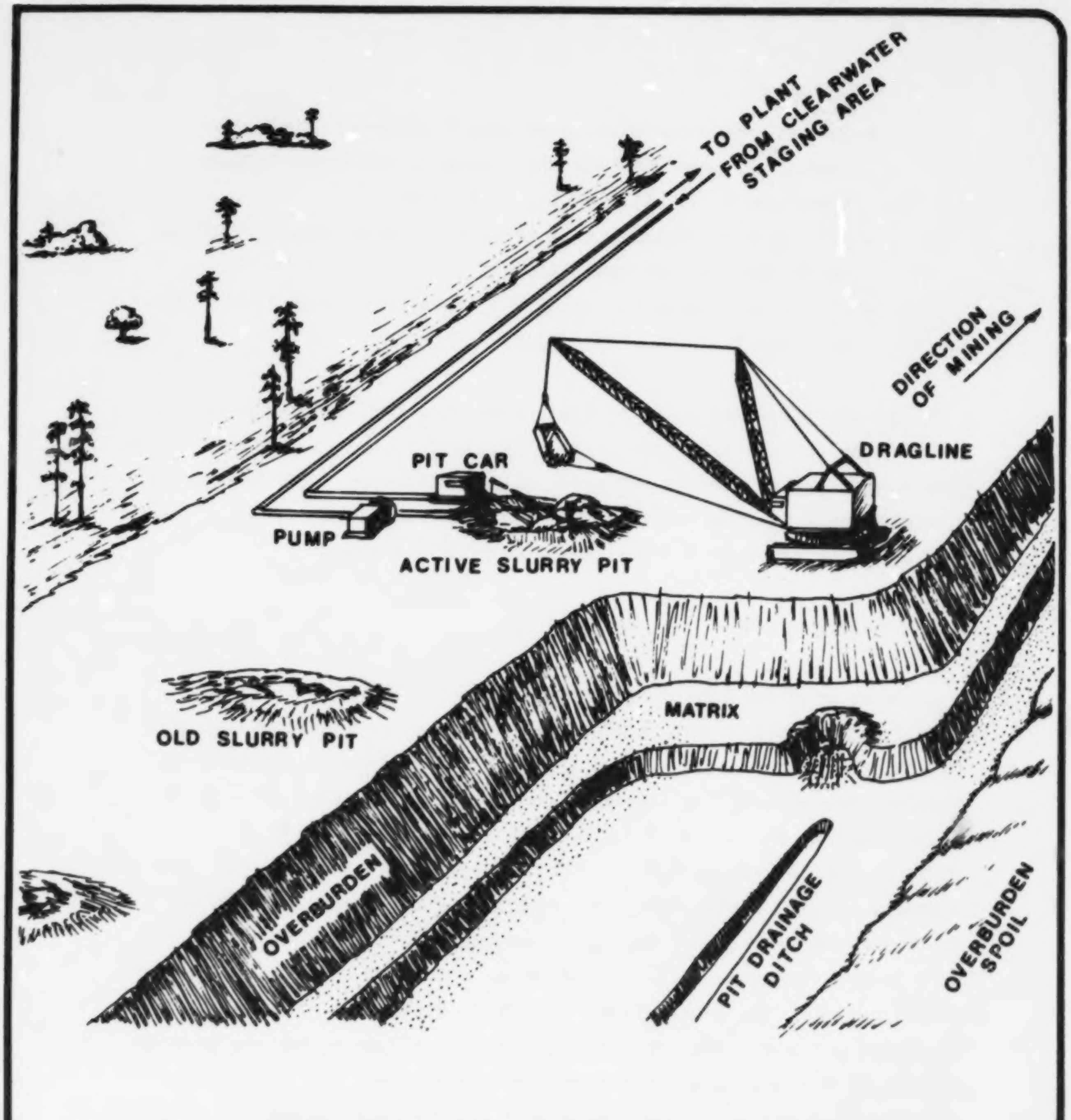
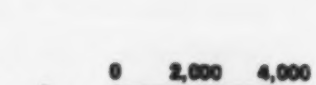

TO PLANT FROM CLEARWATER STAGING AREA
DIRECTION OF MINING
PIT CAR
DRAGLINE
PUMP
ACTIVE SLURRY PIT
MATRIX
OLD SLURRY PIT
OVERBURDEN
PIT DRAINAGE DITCH
OVERBURDEN SPOIL

FIGURE 2-6. CONCEPTUAL VIEW OF DRAGLINE AND SLURRY SYSTEM.


N
0
2,000
4,000
SCALE IN FEET

SOURCE: FARMLAND INDUSTRIES, INC., HARDEE COUNTY MASTER PLAN, JUNE 1979

Farmland's mining sequence has been developed through the use of a computer model which simulates the mining and processing of the entire mineable deposit on an annual basis. The base data for this program come from the prospect drilling results and the preliminary design of the mining and processing equipment. The planned sequence of mining is illustrated in Figure 2-7. Each mining block is designated by year and by relative position within the year (e.g., Block 6B is to be mined in year 6, after Block 6A and before Block 6C).

As currently planned, the total mine life will be 20 years. During this time, 5280 acres are to be disturbed (4951 acres by mining and 329 acres by other facilities such as the beneficiation plant and pipelines). Mining operations will result in the excavation of about 8,700,000 tons of overburden and 9,950,000 tons of matrix annually. The average density (dry basis) of the two materials, overburden and matrix, is approximately 1.25 short tons/cubic yard. The overburden or matrix in its drained condition should contain 15 to 25 percent moisture.

2.1.5 DRAGLINE CROSSINGS

The draglines will occasionally have to cross stream channels. The location of such crossings will be selected to disturb the least total area, particularly the least wetland area. Crossings will be perpendicular to the flow of the streams. In normal years both Oak and Hickory Creeks cease to flow during the dry season. Dragline crossings of these streams will be timed to coincide with the dry, no-flow periods so diversion of the creeks will not be necessary. As currently planned, there will be three one-way crossings of the preserved segment of Oak Creek downstream of Oak Creek Islands. These will occur as follows:

- year 4, from mining block 4A to 4B
- year 6, from mining block 6B to 6C
- year 10, from mining block 10B to 10C

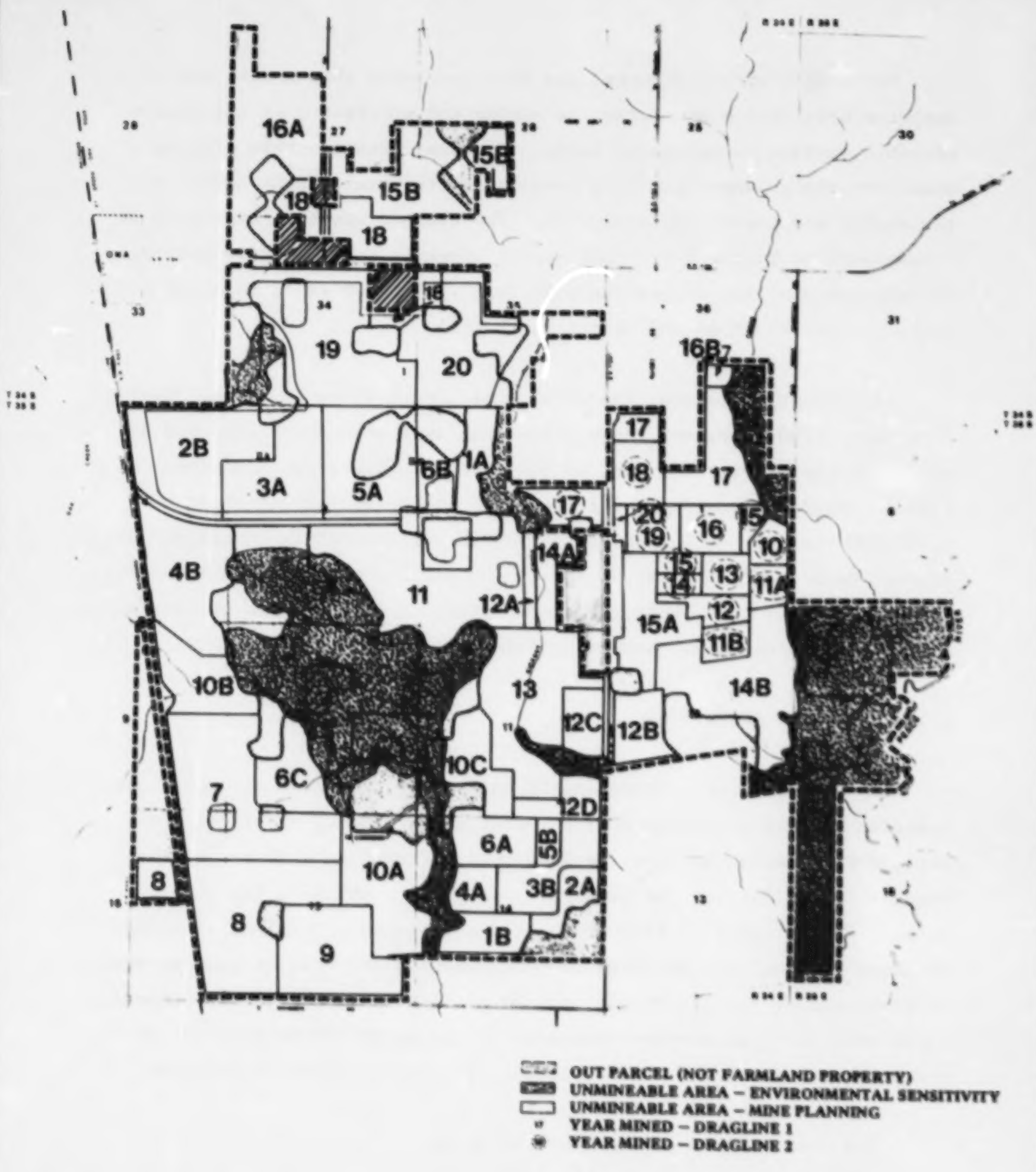

16A
27
15B
15B
18
18
16
19
20
16B
2B
3A
5A
6B
1A
17
18
17
17
20
19
16
15
10
14A
4B
11
12A
15
14
13
11A
12
15A
11B
10B
13
14B
12C
12B
6C
10C
7
12D
6A
5B
8
10A
4A
3B
2A
8
9
1B
28
33
34
35
36
31
30
OUT PARCEL (NOT FARMLAND PROPERTY)
UNMINEABLE AREA – ENVIRONMENTAL SENSITIVITY
UNMINEABLE AREA – MINE PLANNING
YEAR MINED – DRAGLINE 1
YEAR MINED – DRAGLINE 2
N
0
2,000
4,000
SCALE IN FEET

FIGURE 2-7. MINE PLAN SEQUENCING.

SOURCE: FARMLAND INDUSTRIES, INC., DRI, JUNE 1979

Each of these crossings will be made along a single corridor established along the lower portion of Oak Creek Islands (Figure 2-8). The crossing procedure will include clearing existing vegetation and preparing the dragline's path. Vegetation will be established on the approaches to the crossing to prevent erosion and turbid runoff into the streams. Once a crossing has been made, fill introduced into the stream channel will be excavated and the banks immediately stabilized with vegetation. If a particular crossing will be used more than once, the approaches will be maintained until the final crossing is made. These will then be graded to near original contours and the entire disturbed area planted in the type of native vegetation that existed prior to disturbance. Figure 2-9 shows a cross-sectional view of the typical dragline crossing of a stream channel.

In addition to the three planned dragline crossings of the preserved portion of Oak Creek, the mining plans call for dragline crossings of the western portion of Oak Creek (from mining block 4A to 4B) and the prevously diverted northern tributary of Oak Creek (from mining block 4B to 5A). The natural streamcourses in these areas are to be mined.

2.2 SLURRY MATRIX TRANSPORT

2.2.1 GENERAL DESCRIPTION

Farmland plans to use the same matrix slurry transport system used at most existing Florida phosphate mines. This system is briefly summarized in the flow diagram, Figure 2-10. Matrix placed into the slurry pit is mixed with water by use of high pressure nozzles. This breaks down the clay and sand matrix into a slurry which can then be pumped. A series of several large pumps transports the matrix slurry to the plant facilities. The turbulent washing and scrubbing action of the high pressure water nozzles, pumps, and pipeline all contribute to the

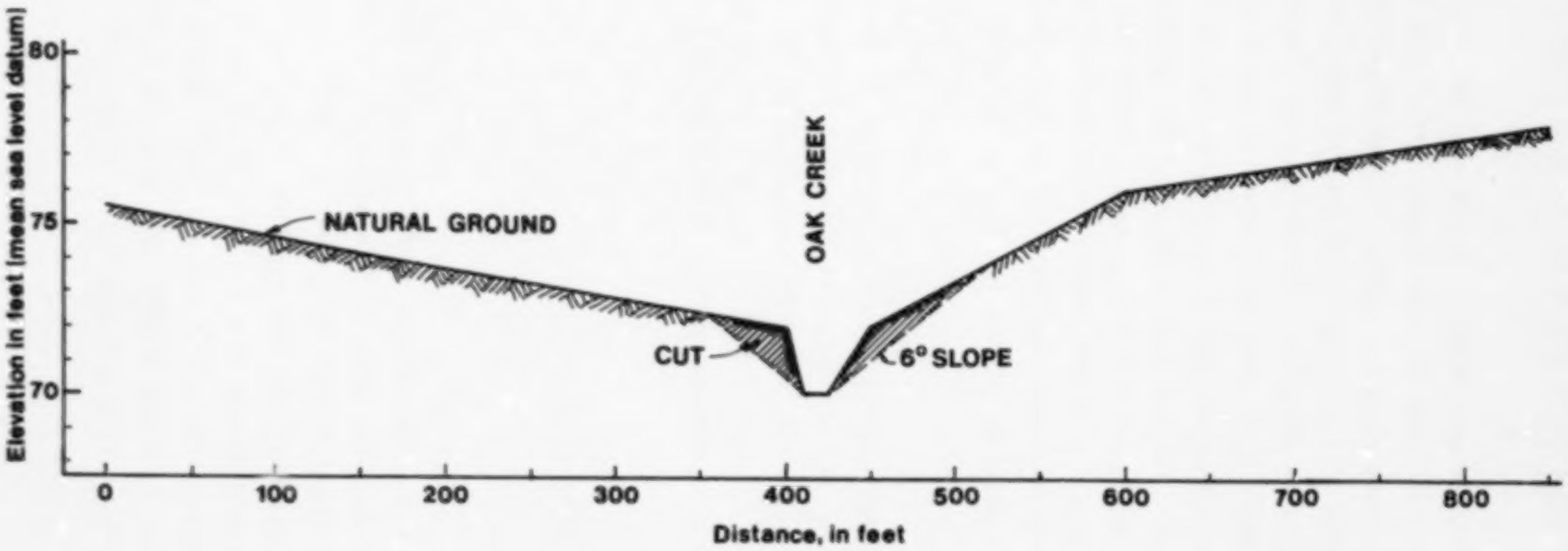
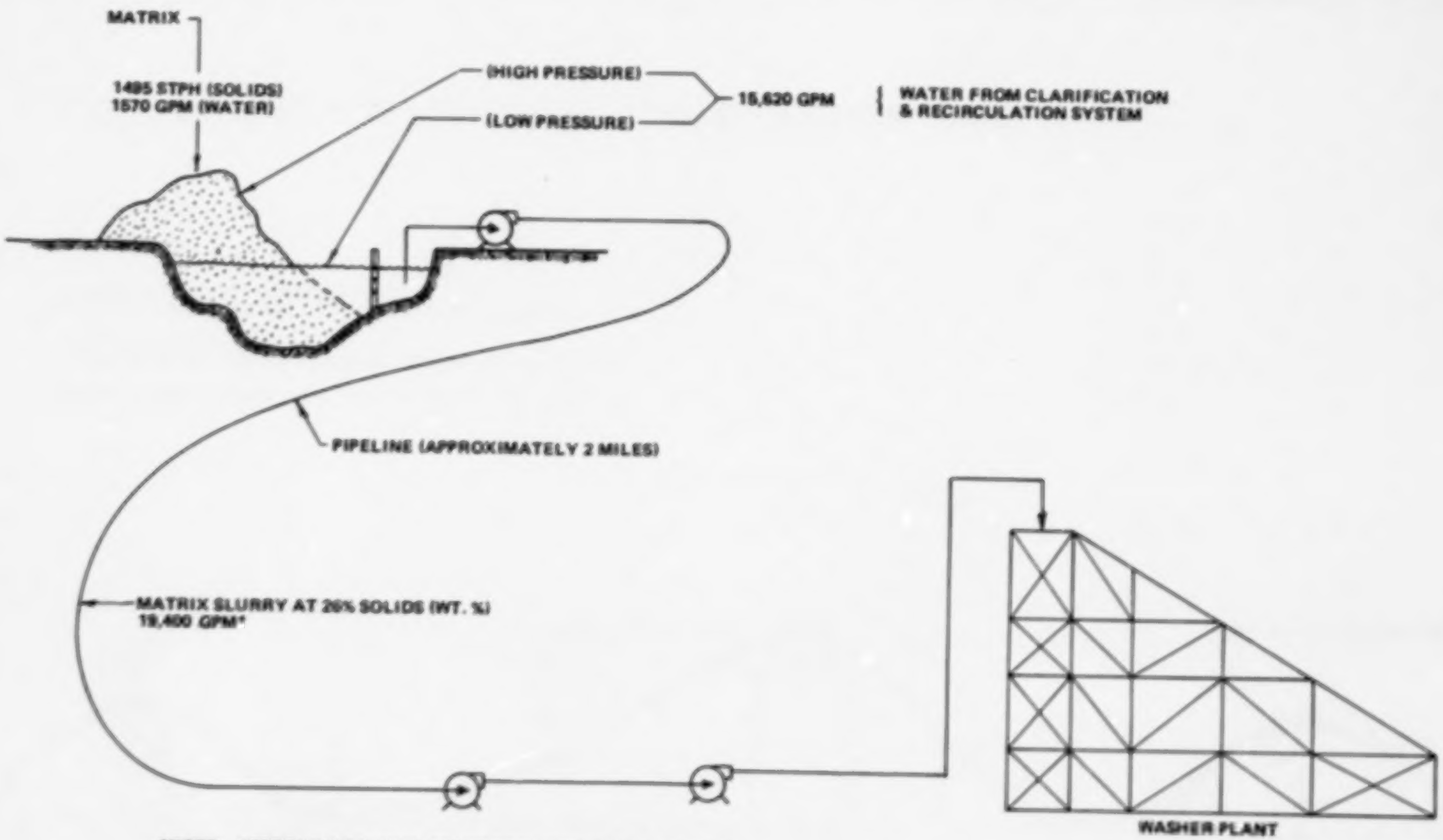


FIGURE 2-8. DRAGLINE CROSSING AT OAK CREEK.

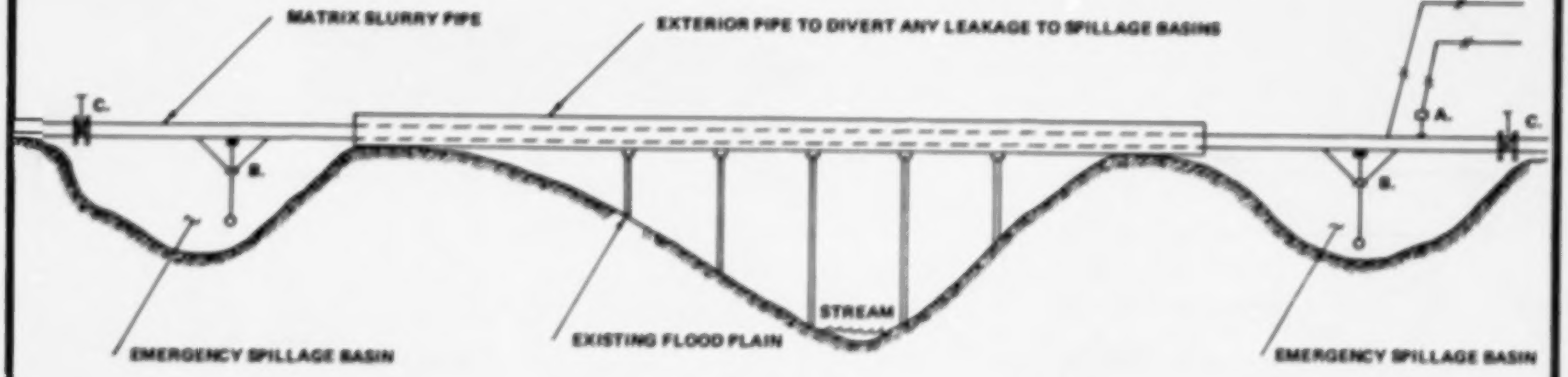
SOURCE: FARMLAND INDUSTRIES, INC., HARDEE COUNTY MASTER PLAN, JUNE 1979


MATRIX
1495 STPH (SOLIDS)
1570 GPM (WATER)
(HIGH PRESSURE)
(LOW PRESSURE)
15,620 GPM
WATER FROM CLARIFICATION & RECIRCULATION SYSTEM
PIPELINE (APPROXIMATELY 2 MILES)
MATRIX SLURRY AT 26% SOLIDS (WT. %)
19,400 GPM*
WASHER PLANT

*NOTE: APPROXIMATELY 85 GPM OF SEAL WATER WILL ALSO BE ADDED TO EACH PUMP WHICH WILL GENERALLY BE ADDITIVE TO THE ABOVE FLOW. THIS WATER WILL COME FROM THE HIGH PRESSURE WATER LINE, FROM ADJACENT RECIRCULATION WATER CANALS, OR FROM SHALLOW SURFACE WATER WELLS

FIGURE 2-9. SCHEMATIC FLOW DIAGRAM FOR SLURRIED MATRIX TRANSPORT.

SOURCE: J.J. CAPE, 1979.


MATRIX SLURRY PIPE
EXTERIOR PIPE TO DIVERT ANY LEAKAGE TO SPILLAGE BASINS
C.
B.
A.
B.
C.
STREAM
EMERGENCY SPILLAGE BASIN
EXISTING FLOOD PLAIN
EMERGENCY SPILLAGE BASIN

A. PRESSURE SENSING DEVICE TO SIGNAL IF LEAKAGE DEVELOPS

B. LEVEL SENSING DEVICES TO SIGNAL THAT SLURRY IS FLOWING INTO SPILLAGE BASINS

C. SHUTOFF VALVES TO SEGREGATE MAIN LINE FROM STREAM CROSSING SECTION AS REQUIRED

FIGURE 2-10. TYPICAL MATRIX PIPELINE CROSSING OF STREAM CHANNEL.

SOURCE: J.J. CAPE, 1979.

processing sequence which follows matrix transport, for the matrix must be broken apart and diluted with water in order to remove the waste clay and silica sand. Not doing so results in a sticky putty like material from which the phosphate could not be recovered with present technology.

Transporting 9,950,000 short tons of sticky matrix to the washing plant each year is a major operation. The horsepower to move the matrix solids and transport water is approximately 3400 HP, assuming an average pumping distance of 10,000 feet. Pumping this slurry is not simply a matter of turning on a single pump, but involves carefully bringing several large pumps on line (in series) so as to prevent surges from throwing tremendous forces against any one pump (which would generally destroy the pump's casing). The density of the slurry must also be properly maintained. Pumping at less than optimum density (e.g., 20 percent solids), does not transfer the required tonnage, and pumping at excessive density can overload the pump motors and/or plug up the system.

Water use in matrix transport is necessary to provide a medium for diluting and carrying the solids. The source of this water can be clarified recycle water from most any source. Water used in the pump seals and the high pressure nozzles must be of high quality. A pump seal is the closure between the rotating shaft and the pump housing. Solids (fine sand in the slurry) within the pump are under pressure and would tend to flow through the opening where the impeller shaft passes through the housing. To avoid this problem, fresh clean water is pumped into the pump housing along the shaft to continually force all solids out of this critical wear point. Particulate or highly corrosive water in the pump seals would also ruin the pump seals and shafts. For these reasons, seal water is generally not taken from the normal recirculating water system unless it is well clarified. Shallow wells will be installed to supply fresh water to the pump seal circuit.

2.2.2 STREAM CROSSINGS

A major concern is the prevention of matrix slurry spillage into the environmentally sensitive areas. The slurry does erode the pipes inner surface, and occasional leaks do occur. To prevent spillage into streams, Farmland will utilize doublewalled pipe and catchment basins at any stream or drainage crossing (Figure 2-11). Any leakage over a stream or crossing will flow within the external pipe or culvert and collect in the depression at either end of the crossing. Pressure sensitive devices (i.e., alarms) will also be installed in the pipeline to alert the operator to such a leakage. Valves will be provided on the slurry pipe to shut off the residual flow in the line and prevent drainage of excessive slurry into the catchment area. One such crossing will be the Oak Creek crossing as shown in Figures 2-8 and 2-12. This site on Oak Creek in Section 11-T35S-R24E has been selected because upland forest, rather than wetlands, predominates in the immediate area. At this crossing several pipelines will be mounted on a trestle structure. A single lane roadway will also be supported by the trestle. An objective of the mine plan has been to minimize the number of such crossings required. The planned crossings include those areas described previously under dragline crossings. When such a crossing is no longer required, the area will be reclaimed by the replanting of native vegetation as dictated by the reclamation plan.

Farmland also expects to provide careful maintenance and inspection of its slurry pipelines to prevent unnecessary leakage. This is desirable not only for the environmental considerations, but any such leakage results in the loss of valuable matrix.

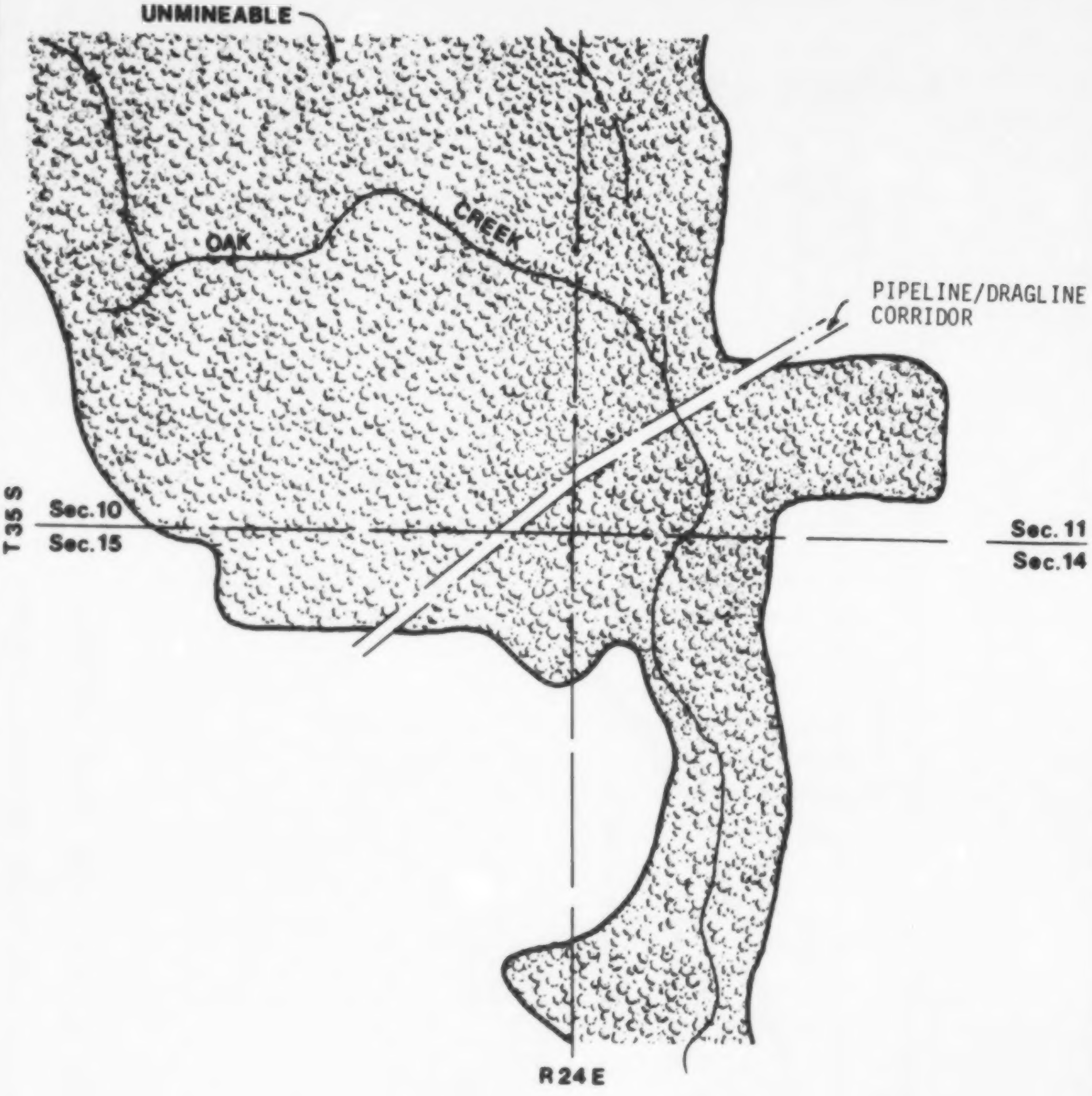
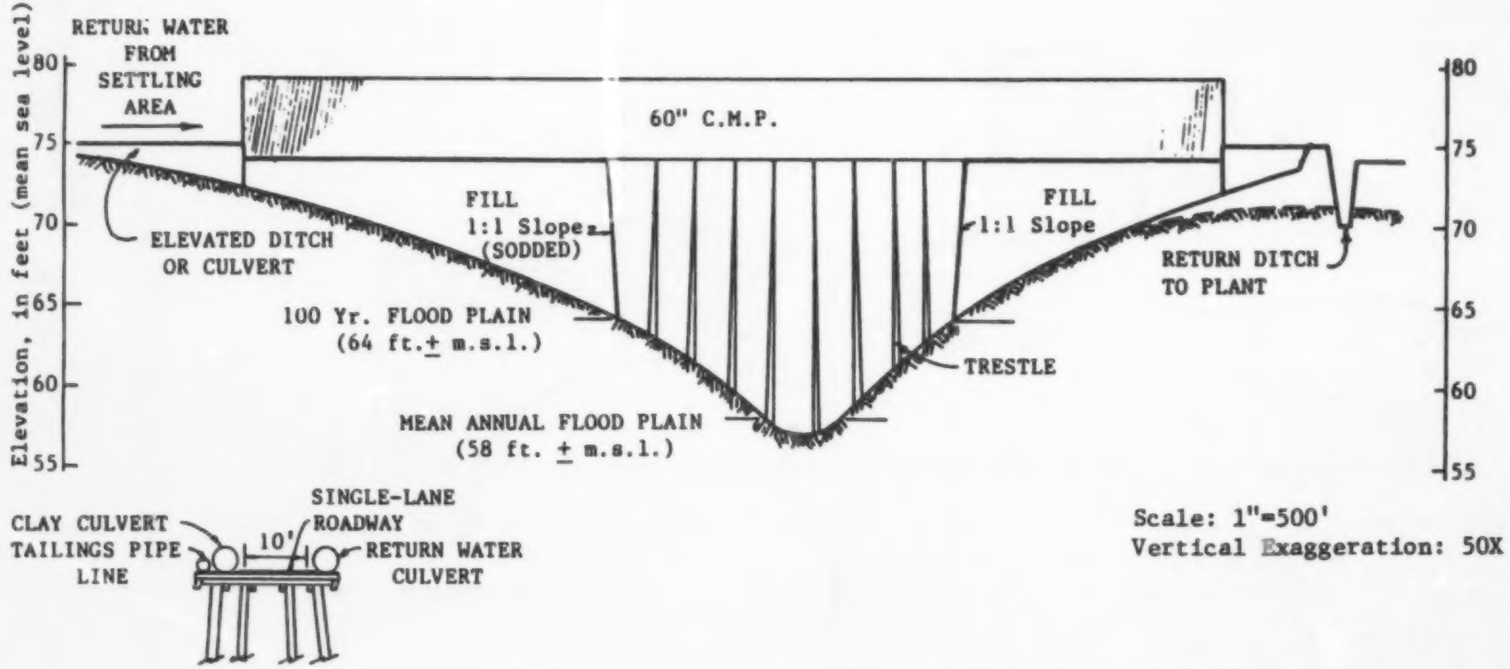

UNMINEABLE
OAK
CREEK
PIPELINE/DRAGLINE CORRIDOR
T 35 S
Sec.10
Sec.15
Sec. 11
Sec.14
R 24 E

FIGURE 2-11. LOCATION OF OAK CREEK PIPELINE CROSSING.

N

Scale
0 500 1000 feet

SOURCE: FARMLAND INDUSTRIES, INC., HARDEE COUNTY MASTER PLAN, JUNE 1979


Elevation, in feet (mean sea level)
80
75
70
65
60
55
RETURN WATER FROM SETTLING AREA
60" C.M.P.
ELEVATED DITCH OR CULVERT
FILL
1:1 Slope
(SODDED)
FILL
1:1 Slope
100 Yr. FLOOD PLAIN
(64 ft.± m.s.l.)
MEAN ANNUAL FLOOD PLAIN
(58 ft. ± m.s.l.)
TRESTLE
RETURN DITCH TO PLANT
CLAY CULVERT TAILINGS PIPE LINE
10'
SINGLE-LANE ROADWAY
RETURN WATER CULVERT

Scale: 1"=500'
Vertical Exaggeration: 50X

FIGURE 2-12. TYPICAL SECTION - OAK CREEK CROSSING.

SOURCE: FARMLAND INDUSTRIES, INC., HARDEE COUNTY MASTER PLAN, JUNE 1979

2.3 MATRIX PROCESSING

2.3.1 PLANT LOCATION

The Farmland Industries ore processing and support facilities will occupy 74 acres located two and a half miles southeast of the Town of Ona (Township 35 South, Range 24 East, Section 2) in Hardee County, Florida. The phosphate beneficiation plant will be laid out on a "T" shaped section of unmineable land located near the ore body epicenter. A preliminary plot plan of the ore processing facilities is shown in Figure 2-13.

2.3.2 PLANT DESCRIPTION SUMMARY

As is characteristic of most Florida phosphate mining operations, the matrix will be slurried, pumped from the mine, and fed to the washer area. In this area, clay and fines will be separated from the pebble size product prior to processing in the flotation plant where additional phosphate product will be recovered. Farmland's facilities are planned to have a nominal capacity of 2,000,000 short tons per year of phosphate rock product. Wet phosphate rock will be stored according to product classification in a storage area with a 1,000,000 short ton capacity. Product load-out facilities and a railroad marshalling yard will be located nearby. A 450-foot diameter thickener will be provided for concentrating waste clays collected in the washing process. The clays will be thickened to provide immediate water recirculation to the plant. Onsite water and sewage treatment will be provided by facilities located in the utility area. Miscellaneous operation support facilities, including the main offices and parking area, will be located within the plant site area.

Electric power lines (tied into the existing Wauchula-Murphy Road Florida Power Corporation 69 KV transmission lines), will enter the

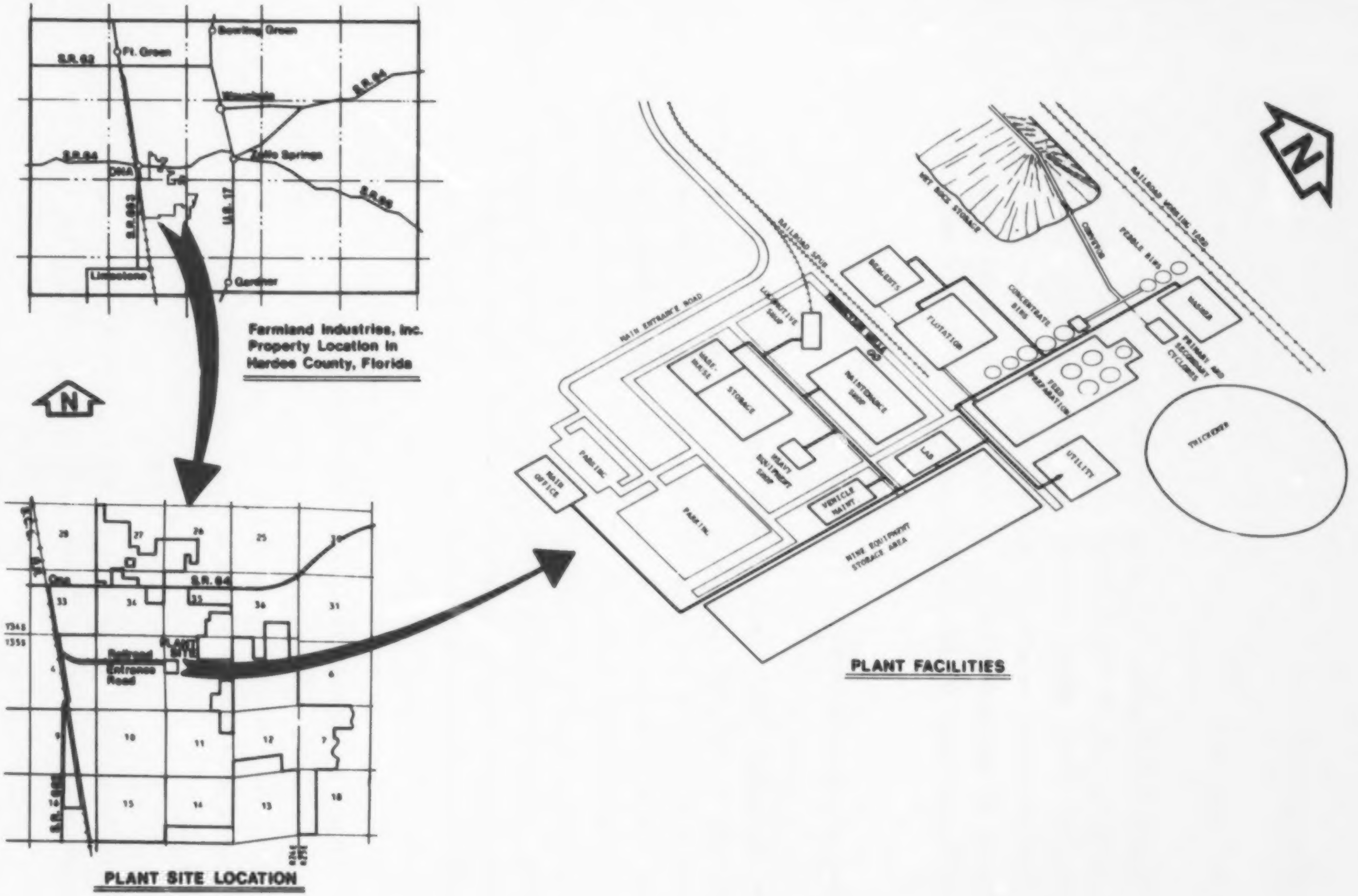

Bowling Green
Ft. Green
S.R. 62
Wauchula
S.R. 64
Zolfo Springs
S.R. 66
Ona
S.R. 663
U.S. 17
Limestone
Gardner
Farmland Industries, Inc.
Property Location in
Hardee County, Florida
N
S.C.L. R.R.
S.R. 64
Railroad
Entrance
Road
PLANT SITE
T34S
T35S
28
27
26
25
30
33
34
35
36
31
4
6
9
10
11
12
7
16
15
14
13
18
S.R. 663
PLANT SITE LOCATION
MAIN ENTRANCE ROAD
RAILROAD SPUR
LOCOMOTIVE SHOP
WET ROCK STORAGE
CONVEYOR
PEBBLE BINS
RAILROAD WORKING YARD
REAGENTS
FLOTATION
CONCENTRATE BINS
WASHER
PRIMARY AND SECONDARY CYCLONES
FEED PREPARATION
THICKENER
WARE-HOUSE
STORAGE
MAINTENANCE SHOP
HEAVY EQUIPMENT SHOP
LAB
UTILITY
VEHICLE MAINT.
PARKING
PARKING
MAIN OFFICE
MINE EQUIPMENT STORAGE AREA
PLANT FACILITIES
N

FIGURE 2-13. BENEFICIATION PLANT FACILITY LOCATIONS.

SOURCE: FARMLAND INDUSTRIES, INC., HARDEE COUNTY MASTER PLAN, JUNE 1979

plant from the east. An 8000-foot long railroad spur, linking the plant with the main line of Seaboard Coast Line Railroad, will enter the plant from the west. As planned, vehicular traffic will use the main entrance road running parallel to the railroad spur and connecting the plant with Florida State Road 663 (Figure 2-13). Whidden Road (to the south) and S.R. 661 (to the east) are not anticipated as entry roads to the plant site.

2.3.3 WASHER AREA

The plant washer area has four main functions:

- to segregate the oversize waste material from the matrix
- to remove the clay by attritioning and cyclone separation
- to separate the sand size fraction so that it can be treated by flotation to recover the fine phosphate particles
- to recover the phosphate rock pebble size particles as a product

A simplified process flowsheet for a typical washer section is shown in Figure 2-14. Matrix, which has been slurried and pumped from the mine, will be fed into the trommel screens which remove clay balls larger than 3/4-inch in diameter. These clay balls will be fed to a hammermill, disintegrated, and sent to the debris disposal area. From the trommel, a series of several types of screens with intermediate log washers will be used to size and clean the pebble. After a final screening to complete the cleaning and dewatering of the pebble (material greater than 1 mm in size), it will be conveyed to the pebble storage bins for chemical analysis prior to storage in the wet rock product pile.

2.3.4 FEED PREPARATION AREA

Material from the washer areas finer than 1 mm (that not separated as pebble) will be fed to hydrocyclones to separate the very fine

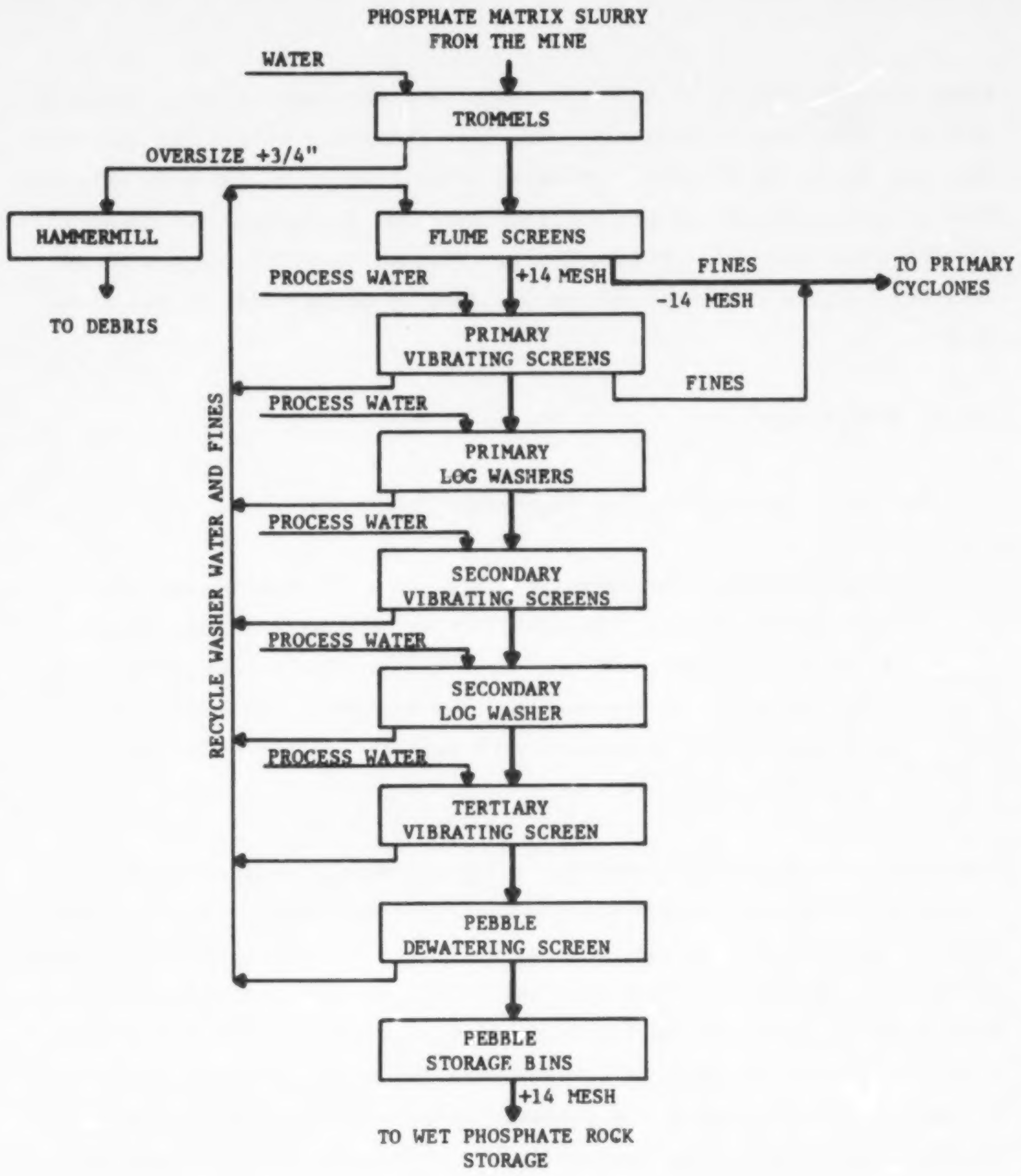

PHOSPHATE MATRIX SLURRY FROM THE MINE
WATER
TROMMELS
OVERSIZE +3/4"
HAMMERMILL
TO DEBRIS
FLUME SCREENS
+14 MESH
FINES
-14 MESH
TO PRIMARY CYCLONES
PROCESS WATER
PRIMARY VIBRATING SCREENS
FINES
RECYCLE WASHER WATER AND FINES
PROCESS WATER
PRIMARY LOG WASHERS
PROCESS WATER
SECONDARY VIBRATING SCREENS
PROCESS WATER
SECONDARY LOG WASHER
PROCESS WATER
TERTIARY VIBRATING SCREEN
PEBBLE DEWATERING SCREEN
PEBBLE STORAGE BINS
+14 MESH
TO WET PHOSPHATE ROCK STORAGE

FIGURE 2-14. WASHER PROCESS FLOWSHEET.

SOURCE: FARMLAND INDUSTRIES, INC., HARDEE COUNTY MASTER PLAN, JUNE 1979

material (minus 0.1 mm), which is mostly clay, from the sand size material called feed. A typical flowsheet for the feed preparation and flotation processes is presented in Figure 2-15. In order for the hydrocyclones to make such a fine separation it is imperative that the clay slurry product from the units does not exceed the range of 3 to 7 percent solids by weight. Substantial amounts of recycled water are used to make this dilution.

The deslimed feed is often sized into coarser and finer fractions and processed separately to improve metallurgical recovery. Feed sizing is performed by screens or hydraulic classifiers. The Farmland feed will be separated into three sizes; very coarse (plus 20 mesh or 0.84 mm), coarse feed (20 x 35 mesh or 0.84 x 0.42 mm), and fine feed (minus 35 mesh or 0.42 mm).

2.3.5 FLOTATION AREA

Flotation procedures consist of four major processing steps:

- coarse and fine rougher flotation circuits to achieve high recovery of phosphate, with bulk rejection of quartz sand tailings
- flotation or similar processing of the very coarse 14 x 20 mesh (1.2 mm x 0.84 mm) phosphate particles
- collection and cleaning of initial concentrates prior to amine flotation
- amine flotation (cleaner)--a second stage of flotation to further concentrate the product

During the initial "rougher" flotation, the feed will be dewatered, conditioned with fatty acid and other reagents, and fed to flotation machines designed to separate the phosphate from the quartz sand particles. The fatty acid coated phosphate particles become air avid and

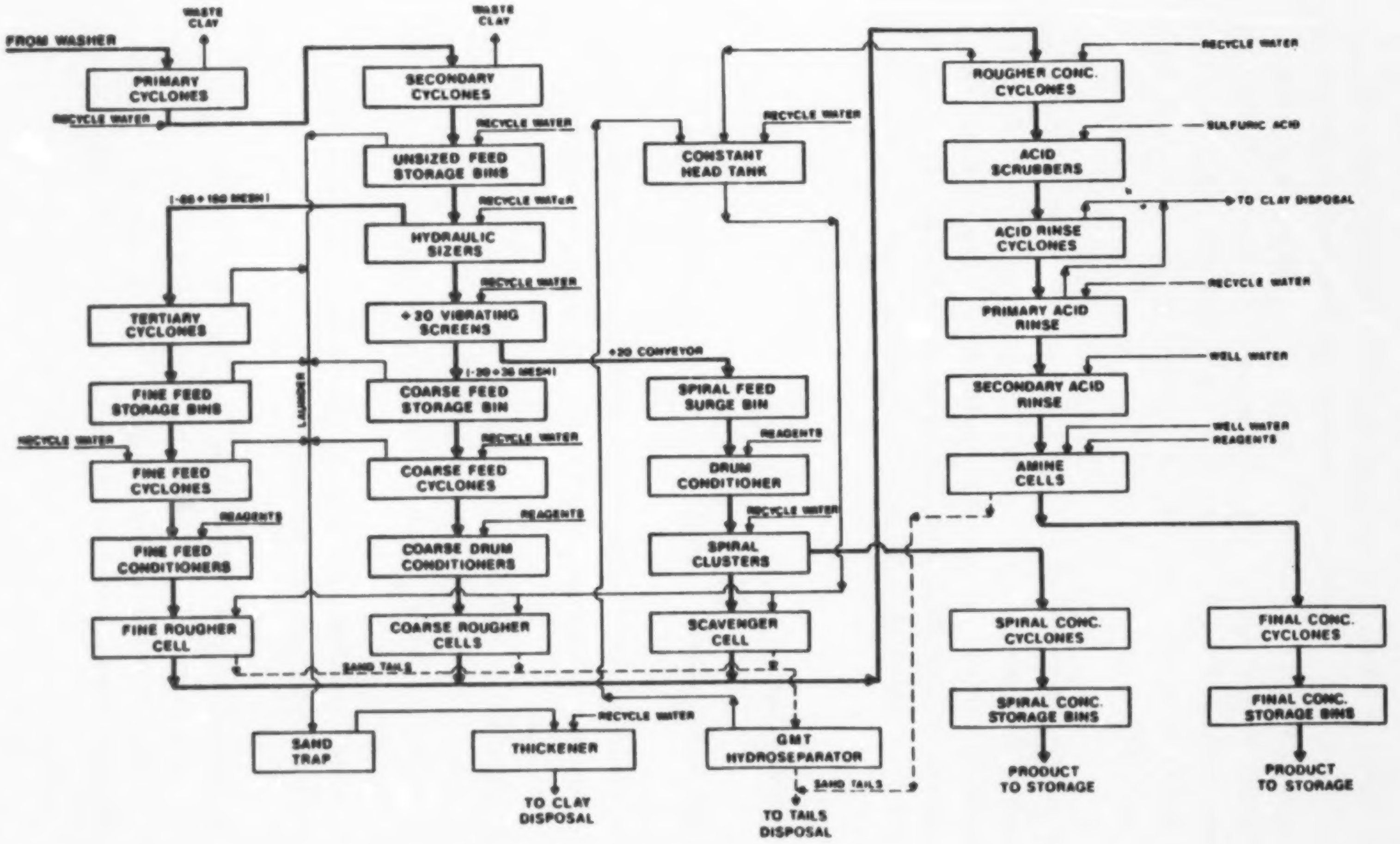

FROM WASHER
WASTE CLAY
PRIMARY CYCLONES
RECYCLE WATER
WASTE CLAY
SECONDARY CYCLONES
RECYCLE WATER
UNSIZED FEED STORAGE BINS
(-35 + 150 MESH)
RECYCLE WATER
HYDRAULIC SIZERS
RECYCLE WATER
+20 VIBRATING SCREENS
TERTIARY CYCLONES
(-20 + 35 MESH)
FINE FEED STORAGE BINS
LAUNDER
COARSE FEED STORAGE BIN
RECYCLE WATER
RECYCLE WATER
FINE FEED CYCLONES
COARSE FEED CYCLONES
REAGENTS
REAGENTS
FINE FEED CONDITIONERS
COARSE DRUM CONDITIONERS
FINE ROUGHER CELL
COARSE ROUGHER CELLS
SAND TAILS
SAND TRAP
THICKENER
RECYCLE WATER
TO CLAY DISPOSAL
RECYCLE WATER
CONSTANT HEAD TANK
+20 CONVEYOR
SPIRAL FEED SURGE BIN
REAGENTS
DRUM CONDITIONER
RECYCLE WATER
SPIRAL CLUSTERS
SCAVENGER CELL
GMT HYDROSEPARATOR
SAND TAILS
TO TAILS DISPOSAL
RECYCLE WATER
ROUGHER CONC. CYCLONES
SULFURIC ACID
ACID SCRUBBERS
TO CLAY DISPOSAL
ACID RINSE CYCLONES
RECYCLE WATER
PRIMARY ACID RINSE
WELL WATER
SECONDARY ACID RINSE
WELL WATER
REAGENTS
AMINE CELLS
SPIRAL CONC. CYCLONES
SPIRAL CONC. STORAGE BINS
PRODUCT TO STORAGE
FINAL CONC. CYCLONES
FINAL CONC. STORAGE BINS
PRODUCT TO STORAGE

FIGURE 2-15. FEED PREPARATION AND FLOTATION FLOWSHEET.

SOURCE: FARMLAND INDUSTRIES, INC., HARDEE COUNTY MASTER PLAN, JUNE 1979

attach to air bubbles floating to the surface. The quartz sand passes through the bottom of the machines. "Rougher" sand tailings (the waste quartz sand material) will then be sent to a hydro-separator where these sands will be concentrated to about 40 percent solids (weight basis) and pumped to waste disposal reclamation areas in the mine.

The phosphate particles collected from the "rougher" stage of concentration will be dewatered, scrubbed with sulfuric acid, and washed free of organics and other material with fresh water prior to the second or "amine" flotation stage. In this stage the material will be conditioned with amine and other reagents which coat the quartz sand. The remaining quartz sand will then be floated away from the phosphate, resulting in an upgraded final phosphate concentrate product. The rinsing before amine flotation and the dilution water added to the amine cells is the main use for fresh (deep well) water. Recycle water utilized in this function would upset the process and result in an unacceptable phosphate product.

The reagents used in processing attach to the quartz sand waste (tailings) particles or remain in the rinse water which flows to join the clay slimes disposal stream.

2.3.6 WET ROCK STORAGE

The wet pebble and concentrate products from the washer and flotation areas, respectively, will be transferred by conveyor belts to an outdoor 1,000,000 ton capacity storage pile (Figure 2-13). A tripper conveyor, located 60 feet above grade, will deposit the rock in piles according to grade and quality. Wet rock will be withdrawn or reclaimed from storage by means of a conveyor located inside a tunnel under the storage pile. All of the products at this point are conveyed wet and pose no particulate problem. Occasionally, when the product is excessively wet, some spillage from the conveyor may occur, but since this is a valuable product it will be continuously cleaned-up and reclaimed. Wet rock moisture into this pile will be approximately 16 percent; after draining during storage, it contains around 12 percent moisture. Any such drainage will be collected and returned to the beneficiation plant circuit.

2.3.7 PHOSPHATE PRODUCT DISPOSITION

About 50 percent of the processed phosphate rock will be rail shipped to Farmland's existing Green Bay chemical plant near Bartow, Florida. The other 50 percent will be rail shipped to a yet to be identified chemical plant for processing. As presently planned by Farmland, all products will be shipped "wet".

2.3.8 PHOSPHATE PRODUCT SPECIFICATIONS

The expected chemical specifications for the Farmland phosphate rock product (dry basis) are listed in Table 2-1.

Production will generally be: pebble, at plus 16 mesh (1mm) - 300,000 tons/year; and concentrate, at minus 16 mesh (1mm) - 1,700,000 tons/year.

Specific gravity of the dry solids is approximately 2.7, or nearly the same as the quartz tailings product.

2.3.9 PLANT CONSTRUCTION

The capital cost for the Farmland mine and beneficiation plant is $55,246,000. Project construction is expected to take 18 months from date of project approval. The construction period is planned as follows:

• Land Clearing	1 Month
• Grading and Excavation	3 Months
• Plant Construction	14 Months
	18 Months

The construction labor force is expected to average 285 workers during this period, with a peak of 400 workers. To the extent possible, Farmland will hire and encourage its contractors to use local workers. A breakdown of the construction expenditures is listed in Table 2-2.

During the 18 month construction period, 1,000 KVA service at the mine site will be adequate to meet all electrical power needs for lighting, pumps, welding, etc. Construction contractors will provide gasoline and diesel fuel for heavy equipment. Energy demand can be expected to fluctuate greatly during the construction period. Total energy requirements during construction are expected to be 750 to 1000 KVA, 250 gal/day gasoline and 225 gal/day of diesel oil.

During the construction phases of the development, the storage facilities for vehicle fuels and lubricants will be small, stationary or portable containers which will be above ground and located on the property as vehicle fuel and lubricant requirements dictate. Such containers will service vehicles and be maintained by the vehicle owners.

Farmland expects the air emissions to be minimal during this period of time. Such emissions will be dust or smoke from heavy machinery, vehicular travel, and open burning. Farmland expects to apply water sprays as needed on unpaved areas and roads during construction. Main roads within the plant area will be paved.

During the construction, provisions of the Hardee County Mining and Earthmoving Ordinance related to air pollution will be complied with in order to minimize adverse impacts.

During the construction phase, perimeter ditches will be installed to collect runoff from the plant site area. Dam construction areas will also be enclosed by perimeter ditches to intercept runoff. In the plant site area, all areas not permanently surfaced will be landscaped and revegetated. Access road shoulders, powerline rights-of-way, and pipeline corridors will be graded and revegetated. All discharges into the natural drainage courses will be monitored to insure that discharged water meets all applicable water quality standards.

2.3.10 OPERATING PERSONNEL AND ENERGY REQUIREMENTS

Operations personnel estimated for the mine and beneficiation plant are listed in Table 2-3.

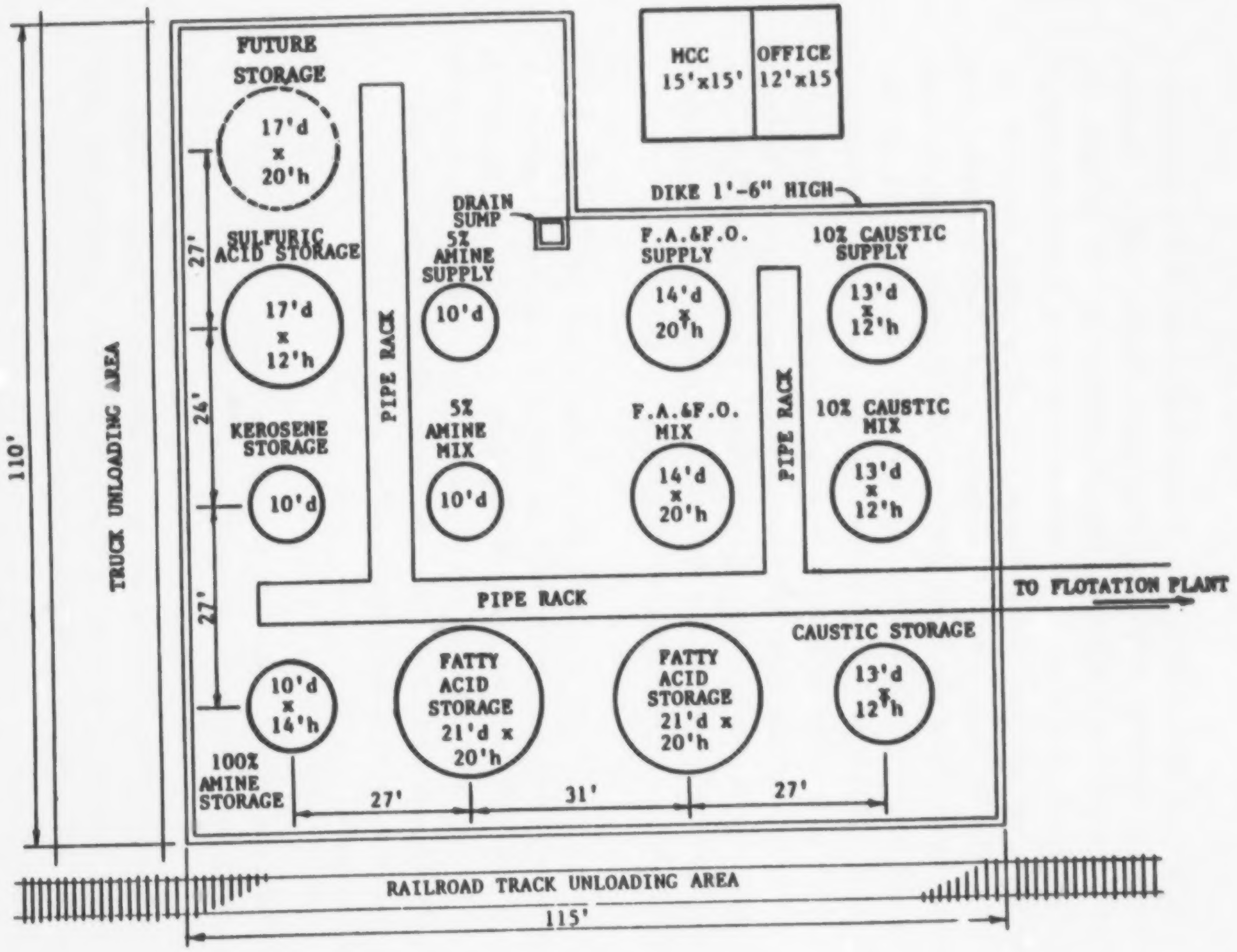
Total electrical energy requirements for the matrix processing facilities and the mine and slurry transport system will average 24,760 KVA. Maximum expected requirements are estimated to be 34,580 KVA. Power for the mine, transport, and matrix processing facilities will pass through a main substation; stepping the voltage down from 69 KV. The present Florida Power substation has a load of approximately 2MW. Adding the new mine load of 2 MVA will load the transmission line to 27 MVA, or 71 percent. It is estimated that 300 gal/day of gasoline and 350 gal/day of diesel oil will also be utilized during plant operation.

2.3.11 REAGENT AND FUEL STORAGE

During the operations phase, storage facilities will be provided for flotation reagents, fuels, and lubricants (Figure 2-12). Storage facilities for reagents for the flotation process will be vertical, cylindrical, steel storage tanks which will be above ground on proper foundations and will be located within a walled or diked tank farm on the beneficiation plant site. In addition to petroleum products, this area will house tanks for fatty acid, caustic materials, sulfuric acid, amine, and amine solutions. The tank farm will include facilities to receive products by tank truck and/or railroad cars, provide storage, mix petroleum products with other reagents as needed, and distribute them by pumping to the flotation area of the plant. Table 2-4 provides pertinent data on the petroleum storage tanks. Figure 2-15 shows a layout of the mine-complex tank farm including the perimeter spillage retaining dike, approximately 1.5 feet high.

Storage facilities for fuels and lubricants for vehicles during the operation phase of development will be located in the vehicle maintenance areas of the plant sites (Figure 2-12). Gasoline and diesel oil will be stored in underground tanks. Lubricating oils will be stored in above ground containers. Storage containers will be of the size and type needed to service the plant vehicles and will be maintained by plant personnel.

Petroleum storage tanks will be built in accordance with API Standard 651 for atmospheric pressure tanks. Tanks will be vented in accordance with API standards. A retaining wall surrounding the tanks will be capable of holding the contents of the largest tank. Valves that could discharge the contents of a tank if opened accidentally will be locked. All tanks will be properly instrumented to prevent overfilling.



FUTURE STORAGE
17'd x 20'h
SULFURIC ACID STORAGE
17'd x 12'h
KEROSENE STORAGE
10'd
10'd x 14'h
100% AMINE STORAGE
MCC 15'x15'
OFFICE 12'x15'
DIKE 1'-6" HIGH
DRAIN SUMP
5% AMINE SUPPLY
10'd
5% AMINE MIX
10'd
F.A.&F.O. SUPPLY
14'd x 20'h
F.A.&F.O. MIX
14'd x 20'h
10% CAUSTIC SUPPLY
13'd x 12'h
10% CAUSTIC MIX
13'd x 12'h
CAUSTIC STORAGE
13'd x 12'h
FATTY ACID STORAGE 21'd x 20'h
FATTY ACID STORAGE 21'd x 20'h
PIPE RACK
PIPE RACK
PIPE RACK
TO FLOTATION PLANT
TRUCK UNLOADING AREA
RAILROAD TRACK UNLOADING AREA
110'
115'
27'
24'
27'
27'
27'
31'
27'

FIGURE 2-16. REAGENT STORAGE AREA - BENEFICIATION PLANT.

SOURCE: FARMLAND INDUSTRIES, INC., DRI, JUNE 1979

The following precautions will be taken:

- No unauthorized personnel will be allowed in the fenced off tank farm area.
- Only authorized personnel will have keys for locked valves and will be permitted to operate pumps, valves, and controls.
- Unloading connections will be properly labeled and securely capped.
- The tank farm area will be well lighted so that spills and leakage can be detected.
- Operating and maintenance personnel will be trained in the use of oil drainage and collection equipment.
- Vapor emission points will be visually checked periodically.

The tank farm area will have a layer of crushed limerock gravel approximately 2 feet deep that will be level with the tank foundations. The slope of the ground within the tank farm retention area will direct all spillages and rainfall runoff to a drainage sump equipped with a manually operated electric motor-driven sump pump. Rainfall runoff and spillages, if any, will be pumped to the flotation plant sand trap, where they will enter the mine water recirculating system. Any spillage from the tank farm will subsequently be adsorbed by the clay in the flotation plant sand trap effluent and removed in clarification.

In the event of accidental spillage of the contents of a storage tank, the drainage sump pump will be used to return the spillage to that tank. Consequently, there should be no discharge from the tank farm retaining area in the event of a major accidental spillage. In addition, the entire plant site areas will be enclosed by a perimeter ditch to intercept runoff. Figure 2-17 shows a schematic of the spillage and runoff collection system for the tank farms.

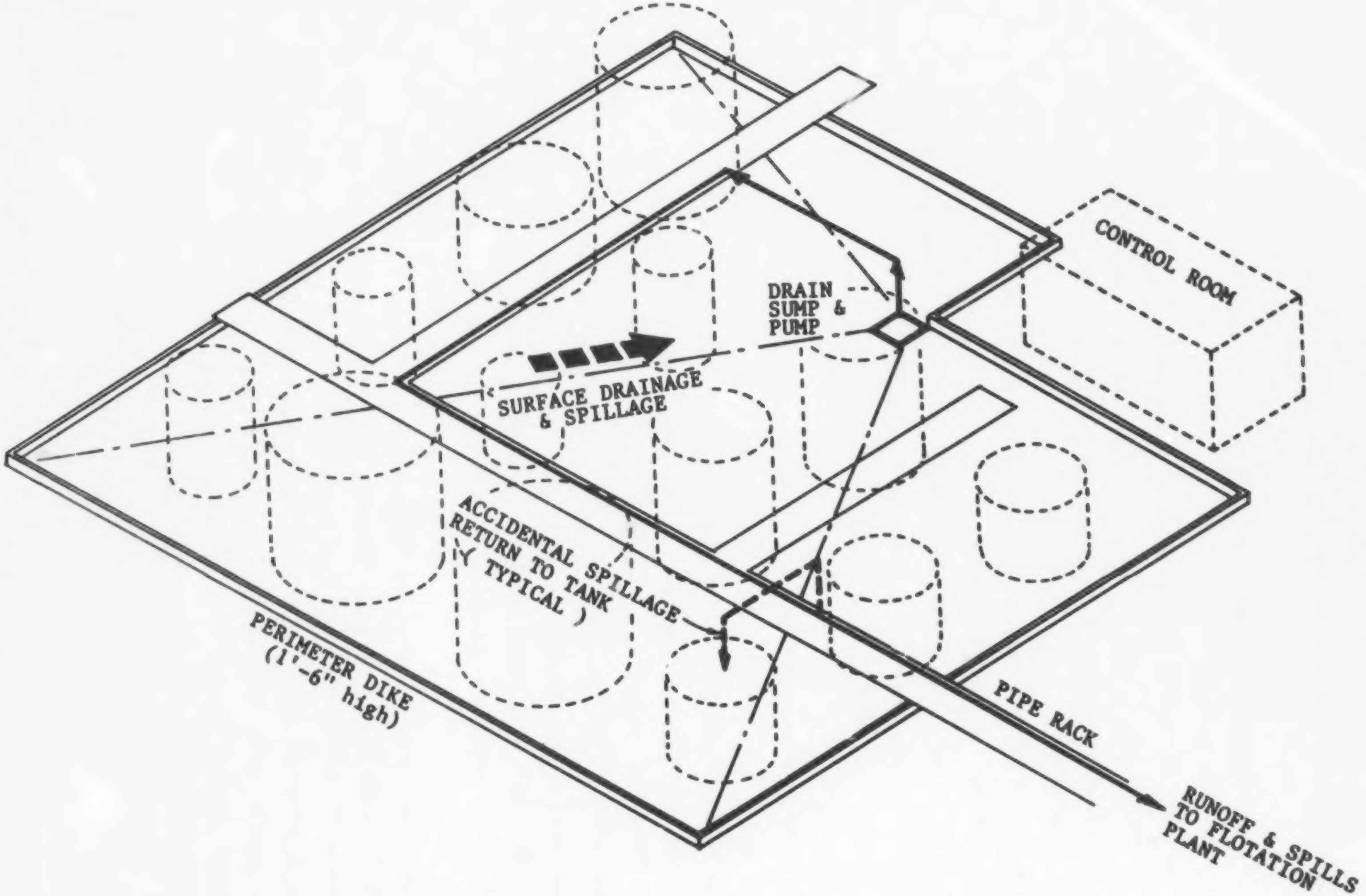

CONTROL ROOM
DRAIN SUMP & PUMP
SURFACE DRAINAGE & SPILLAGE
ACCIDENTAL SPILLAGE RETURN TO TANK (TYPICAL)
PERIMETER DIKE (1'-6" high)
PIPE RACK
RUNOFF & SPILLS TO FLOTATION PLANT

FIGURE 2-17. REAGENT STORAGE AREA RUNOFF AND SPILLAGE COLLECTION SYSTEM - BENEFICIATION PLANT.

SOURCE: FARMLAND INDUSTRIES, INC., DRI, JUNE 1979

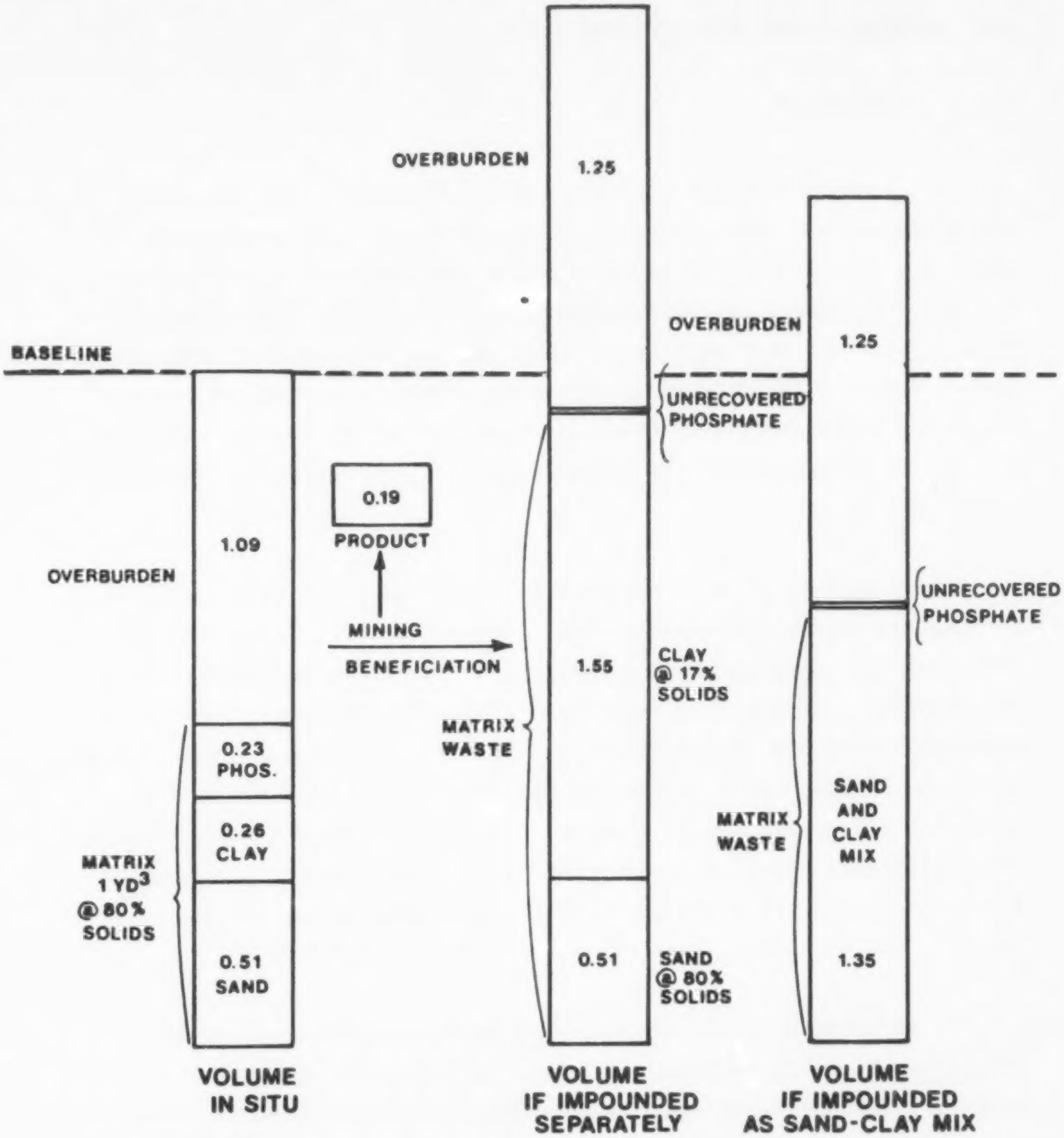
2.4 WASTE SAND AND CLAY DISPOSAL PLAN

2.4.1 METHODOLOGY

The beneficiation of phosphate matrix results in the separation of two solid wastes--quartz sand tailings and clays. The quartz sand is minus 1 mm to plus 0.1 mm in size, while the clays are nominally minus 0.1 mm. On the average approximately 1.0 ton of clay solids and 2.6 tons of tailings sand will be produced per ton of phosphate rock product. Figure 2-18 illustrates the relationship of the various matrix constituents in average matrix. It should be noted, however, that the sand and clay content of the matrix over the site varies significantly from these figures.

Under current plans, the majority of the sand and clay wastes will be disposed through the sand-clay mix technique. Refinement of the sand-clay mix technique is presently receiving research emphasis from the industry. During the early years of mining, Farmland plans to experiment with the most up-to-date techniques available. Based on this research, Farmland will select the sand-clay technique that is best suited to its particular conditions. Ideally, a method will be developed which will result in the formation of a sand-clay mix at about a 2.5:1 ratio, roughly the same ratio as that found in the matrix. However, ratios ranging from 1.9:1 to 3.1:1 are planned.

In addition to sand-clay mixing, Farmland proposes to utilize conventional (i.e., separate) sand and clay disposal methods on a limited basis. Such methods are considered necessary because of the need to (1) store these waste until sufficient mined out area is available for below ground disposal; and (2) maintain the sand:clay ratio in following years within acceptable ranges for successful sand-clay mixing. Separate disposal areas will be necessary over the life of the mine to receive the sand and clay waste periodically generated in excess of the capabilities of the sand-clay mix process.



OVERBURDEN
1.25
OVERBURDEN
1.25
BASELINE
UNRECOVERED PHOSPHATE
0.19
PRODUCT
1.09
OVERBURDEN
MINING
BENEFICIATION
1.55
CLAY @ 17% SOLIDS
UNRECOVERED PHOSPHATE
MATRIX WASTE
0.23 PHOS.
0.26 CLAY
MATRIX 1 YD^3 @ 80% SOLIDS
0.51 SAND
0.51
SAND @ 80% SOLIDS
MATRIX WASTE
SAND AND CLAY MIX
1.35
VOLUME IN SITU
VOLUME IF IMPOUNDED SEPARATELY
VOLUME IF IMPOUNDED AS SAND-CLAY MIX

NOTE: VOLUMES ARE IN YD^3.
0.19 YD^3 OF PRODUCT = 0.25 TONS OF PRODUCT.

FIGURE 2-18. MATRIX COMPOSITION AND WASTE VOLUME RELATIONSHIPS.

SOURCE: FARMLAND INDUSTRIES, INC., DRI, JUNE 1979

2.4.2 DISPOSAL AREAS

The sequencing and type(s) of waste materials placed in given areas are, to a large extent, controlled by objectives of the reclamation plan. As indicated previously, the following two waste disposal approaches are planned for Farmland's mining operation:

- disposal of a mixture of sand and clay in common backfill areas (i.e., sand-clay mix)
- disposal of sand and clay wastes in separate areas (i.e., conventional sand and clay disposal)

Figure 2-19 shows the locations and extent of the various waste disposal areas planned for the mine site. Separately stored sands and clays will be disposed of within diked areas encompassing about 1100 acres of the site (Settling Area I - 495 acres; Settling Area II - 583 acres). Settling Area I will be constructed on unmined land prior to the beginning of mine operation and will receive all clay wastes generated during the initial years of operation. Settling Area II will be constructed within areas of the site mined during the first 6 years of operation. Parts of Settling Area II will be used for clay disposal as early as year 2 of operation, and the entire area will remain active through the life of the mine. By the end of mining this area will have been filled with clays to about 35 feet above natural ground level.

Since Settling Area I is to be constructed on unmined land, the waste clays deposited over this area will have to be removed in order to recover the underlying phosphate matrix in the last 2 years of mining. These clays, which will have been dewatered to a higher percent solids than when originally deposited, will be dredged and used as the clay input to a special sand-clay mix to be used in the reclamation of the mined portion of Oak Creek adjacent to the west side of Oak Creek Islands (Mix 1 and Mix 2 areas in Figure 2-19) and in the headwaters of

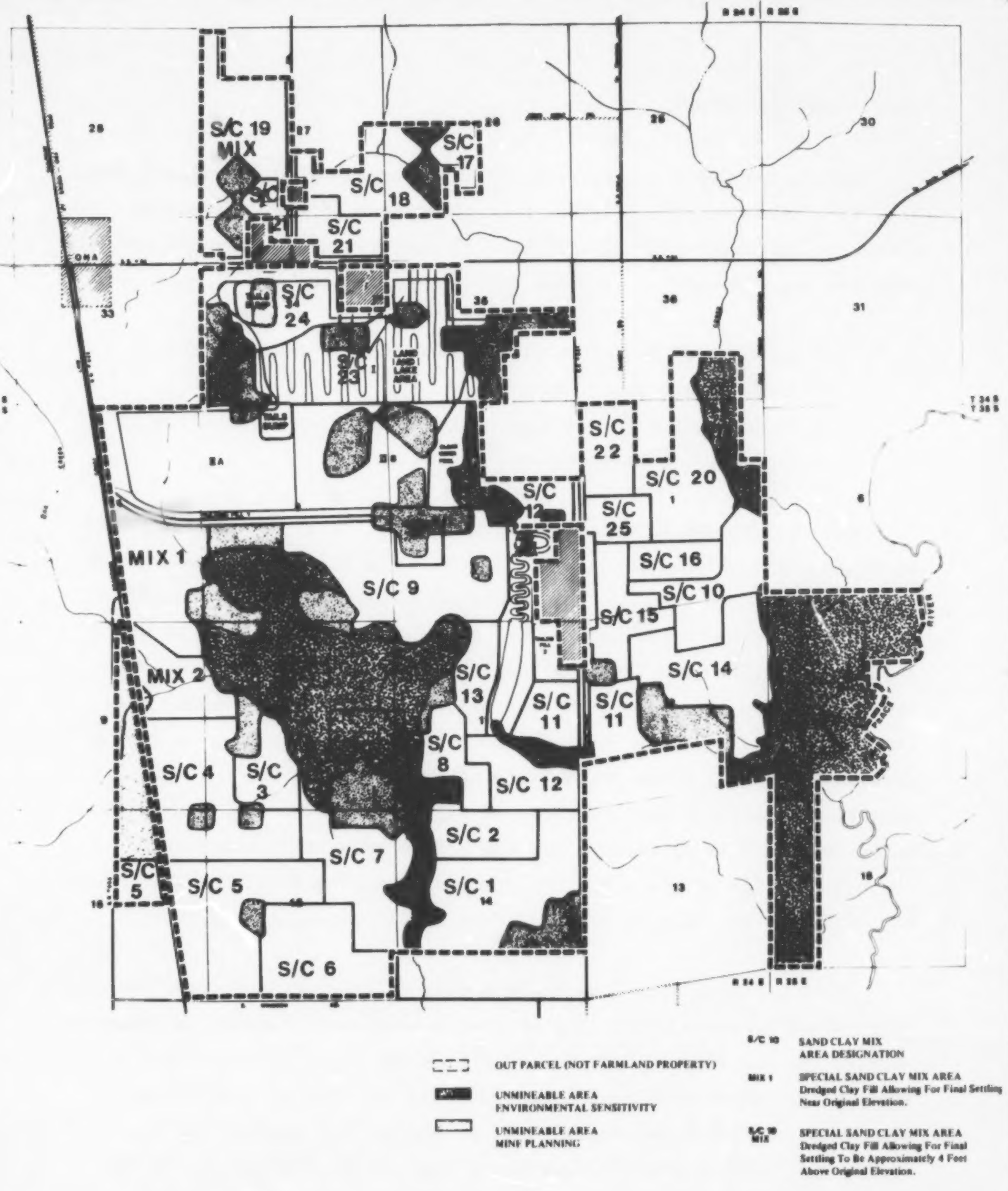

S/C 19 MIX
S/C 17
S/C 18
S/C 21
S/C 24
S/C 23
S/C 22
S/C 20
S/C 12
S/C 25
S/C 16
S/C 10
S/C 15
S/C 14
S/C 9
MIX 1
MIX 2
S/C 13
S/C 11
S/C 11
S/C 8
S/C 12
S/C 4
S/C 3
S/C 2
S/C 7
S/C 5
S/C 5
S/C 1
S/C 6
ONA
RIVER
T 34 S
T 35 S
R 24 E
R 25 E
OUT PARCEL (NOT FARMLAND PROPERTY)
UNMINEABLE AREA ENVIRONMENTAL SENSITIVITY
UNMINEABLE AREA MINE PLANNING
S/C 10 SAND CLAY MIX AREA DESIGNATION
MIX 1 SPECIAL SAND CLAY MIX AREA Dredged Clay Fill Allowing For Final Settling Near Original Elevation.
S/C 19 MIX SPECIAL SAND CLAY MIX AREA Dredged Clay Fill Allowing For Final Settling To Be Approximately 4 Feet Above Original Elevation.

FIGURE 2-19. SAND-CLAY WASTE DISPOSAL PLAN.

N

0 2,000 4,000

SCALE IN FEET

SOURCE: FARMLAND INDUSTRIES, INC., HARDEE COUNTY MASTER PLAN, JUNE 1979

Hickory Creek (S/C 19 mix area in Figure 2-19). Removal of clays from Settling Area I for reclamation in Mix 1 and Mix 2 areas will begin in year 5 of operation and continue through at least year 12. The placement of dredged clays in the S/C 19 mix area will occur following the mining of that area in year 18. Clays from Settling Area II will also be deposited in Area II as necessary.

As in the case of clay wastes, sand tailings generated during the initial years of operation will be disposed of on unmined land within Settling Area I. These will be located within this area over a 77-acre area not to be mined in later years. A 27-acre area of Settling Area II will also be reserved for sand tailing disposal. Like the remainder of Area II, this disposal area will be over mined land and will remain in place after mining of the site is completed.

Deposition of sand tailings and clay into mined areas as a sand-clay mix is scheduled to begin during the fourth year of operation and continue through the life of the mine. A total of 3915 acres of sand-clay mix landfills are planned (Figure 2-19), which amounts to 79 percent of the area to be mined.

2.4.3 IMPOUNDMENT STRUCTURES

Waste clay materials, whether mixed with sand or disposed separately, will be impounded behind above-grade retention dams. Impoundment above-grade is necessary to allow for future subsidence of the wastes as they dewater and to provide for decantation, drainage, and recirculation of the water liberated during settling.

The following three types of waste impoundment structures are currently planned for the Farmland site:

- retention dams for sand-clay mix landfills in mined out areas

- retention dams for clays impounded on unmined ground (Settling Area I)
- retention dams for clays impounded in mined out areas (Settling Area II)

The dam designs for each of these impoundments are shown in Figures 2-20, 2-21, and 2-22.

The clay retention dams are planned to have an average height of 41 feet above-grade (see Figures 2-21 and 2-22), but filled no higher than 35 feet above-grade. Setbacks required by the Hardee County Mining and Earthmoving Ordinance have been followed in planning the location of these dams.

The retention dams employed in sand-clay mix landfills are the most extensive impoundment structures planned. These dams will consist of overburden cast by the dragline and will have relatively low downslope gradients (see Figure 2-20). Most of these dams are designed to be only 17 feet in height, with the maximum average height planned for any sand-clay retention areas being only 20 feet. Because of the low height and gradual slope of these dams, they will represent a relatively low profile on the landscape. The waste disposal plan provides for the construction of sand-clay retention dams within 100 feet of Farmland's boundary, except in the vicinity of permanent buildings (where the required 500-foot offset is followed). The plan will allow the construction of dams with lower heights.

The design and construction of dams required for the impoundment of clay and sand-clay wastes will comply with all provisions of Chapter 17-9 of the Florida Administrative Code. A professional engineer registered in Florida and experienced in earthen dam design will be responsible for the design of all retention dams built on the property. Prior to construction of each dam, the engineer will conduct a soil sampling and testing program to insure that the foundation material will support the

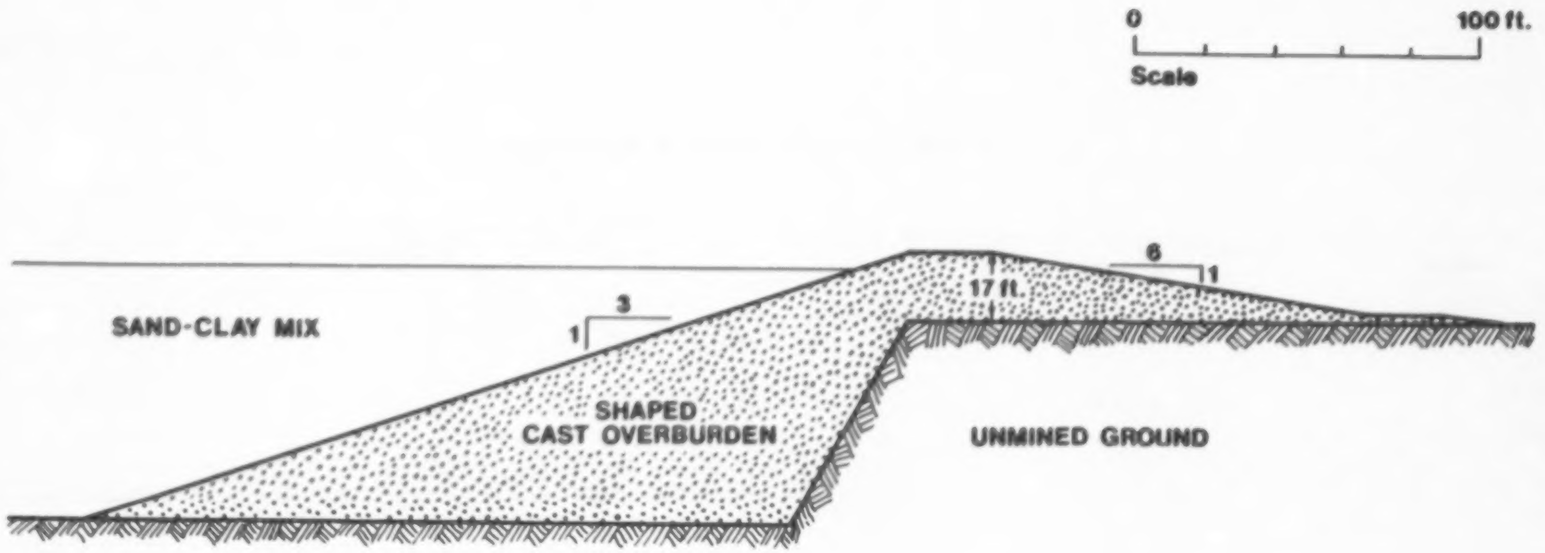
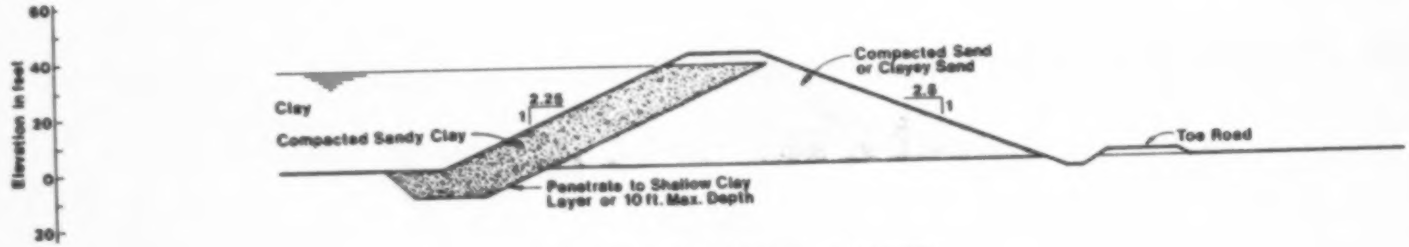
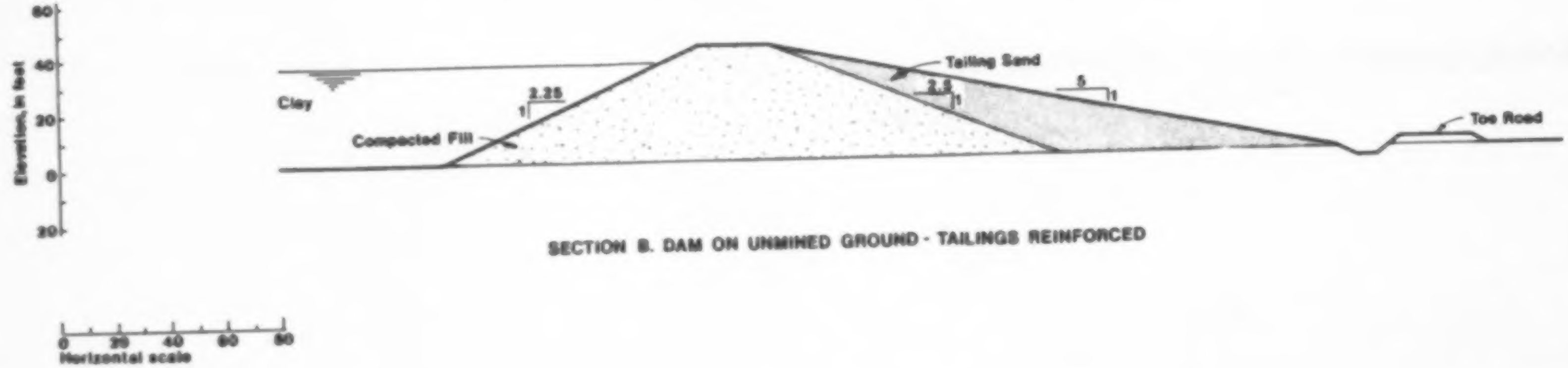

0
100 ft.
Scale
SAND-CLAY MIX
1
3
SHAPED
CAST OVERBURDEN
17 ft.
6
1
UNMINED GROUND

FIGURE 2-20. RETENTION DAM DESIGN FOR SAND-CLAY MIX LANDFILLS IN MINED-OUT AREAS.

SOURCE: FARMLAND INDUSTRIES, INC., HARDEE COUNTY MASTER PLAN, JUNE 1979


60
40
20
0
20
Elevation in feet
Clay
Compacted Sandy Clay
2.25
1
Penetrate to Shallow Clay Layer or 10 ft. Max. Depth
Compacted Sand or Clayey Sand
2.8
1
Toe Road

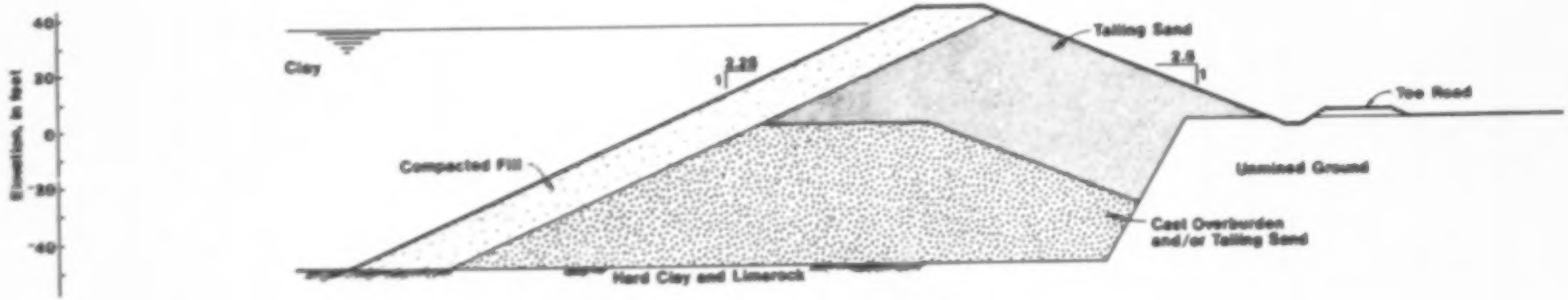
SECTION A. DAM ON UNMINED GROUND


60
40
20
0
20
Elevation, in feet
Clay
Compacted Fill
2.25
1
Tailing Sand
2.8
1
5
1
Toe Road
0
20
40
60
80
Horizontal scale

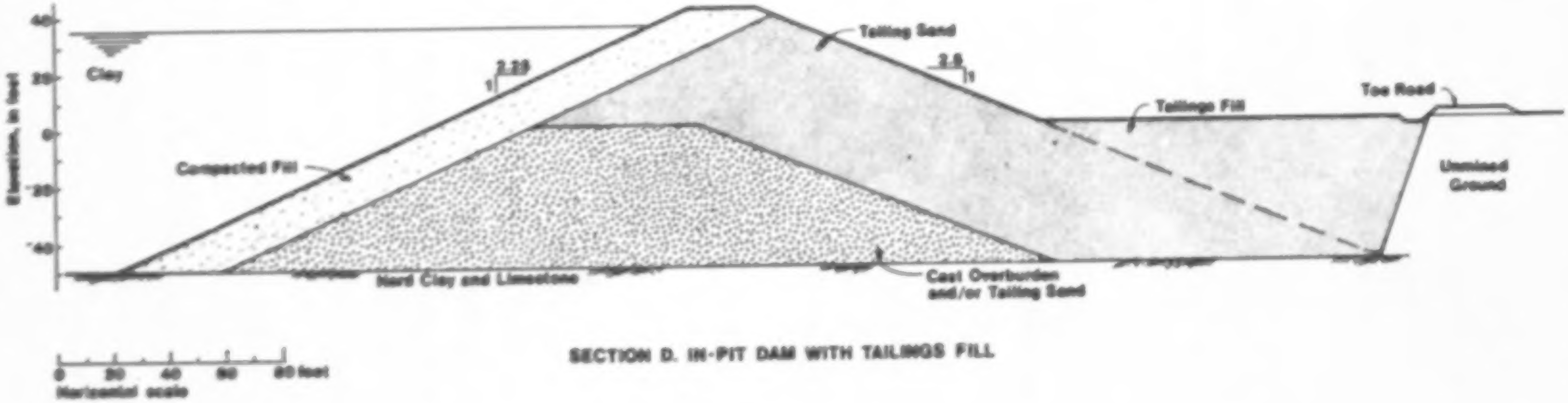
SECTION B. DAM ON UNMINED GROUND - TAILINGS REINFORCED

FIGURE 2-21. RETENTION DAM DESIGN FOR CLAY IMPOUNDMENT AREAS ON UNMINED GROUND.

SOURCE: FARMLAND INDUSTRIES, INC., HARDEE COUNTY MASTER PLAN, JUNE 1979


40
20
0
-20
-40
Elevation, in feet
Clay
1
2.25
Compacted Fill
Tailing Sand
2.5
1
Toe Road
Unmined Ground
Cast Overburden and/or Tailing Sand
Hard Clay and Limerock

SECTION C. IN-PIT DAM - TAILINGS REINFORCED


40
20
0
-20
-40
Elevation, in feet
Clay
1
2.25
Compacted Fill
Tailing Sand
2.5
1
Tailings Fill
Toe Road
Unmined Ground
Cast Overburden and/or Tailing Sand
Hard Clay and Limestone
0
20
40
60
80 feet
Horizontal scale

SECTION D. IN-PIT DAM WITH TAILINGS FILL

FIGURE 2-22. RETENTION DAM DESIGN FOR CLAY IMPOUNDMENTS ON MINED GROUND.

SOURCE: FARMLAND INDUSTRIES, INC., HARDEE COUNTY MASTER PLAN, JUNE 1979

proposed dam, and that the soils will be suitable for the construction of earthen embankments. During construction, the design engineer will maintain qualified personnel onsite to insure that construction is carried out according to his design.

When construction is complete, the dam faces will be planted in grasses to inhibit wind and water erosion. The vegetative cover will be mowed as necessary to allow visual inspection of the dam surface at all times.

An inspection plan for all dams will adhere strictly to the provisions of the Hardee County Mining and Earthmoving Ordinance and Chapter 17-9 of the Florida Administrative Code. Piezometers will be installed in the dams to monitor the water level and seepage patterns within the embankment. These piezometers will be read regularly throughout the active life of the impoundment. The readings will be analyzed by an engineer to insure that they conform to the design features.

All dams will be inspected daily by a Farmland employee who has been instructed by the design engineer. This inspection will consist of an examination of the vegetative and soil cover, the piezometer levels, the elevation of the impounded water and the amount of freeboard remaining on the dam, the condition of drainage ditches around the base of the dam, and the condition of all spillways and water control structures. A monthly report summarizing the results of the daily inspections will be submitted to the Hardee County Board of County Commissioners and the Building Department.

The design engineer or another comparably qualified engineer will make annual inspections of all the retention dams on the property. The engineer's annual inspection will include an analysis of the piezometer readings collected during the previous year and a review of all weekly inspections reports to evaluate the effectiveness of the maintenance program followed since the last annual inspection. The engineer will submit his findings in writing to the Florida Department of Environmental Regulation.

In addition to the waste disposal areas, waste clays will be temporarily impounded in a 450-foot-diameter (3.7 acre) thickener at the beneficiation plant. As currently planned, this thickener will be constructed on natural ground and enclosed by an earthen berm about 10 feet in height. The fluid level in the thickener will be maintained at approximately 4 feet above natural grade to provide for gravity return of clarified water to the beneficiation plant. The earthen berm for the thickener will be designed and constructed in a like manner to the retention dam for Settling Area I (also constructed on natural ground).

2.5 MINE WATER USE PLAN

2.5.1 PROCESS WATER REQUIREMENTS

In matrix transport and processing, water is used for the following purposes:

- Ore Transportation--Recycled water is required to slurry the matrix, and as a medium for transporting the matrix to the beneficiation plant.
- Washer and Feed Preparation Process--Recycled water is used in the washing process to separate pebble, sand, and clay size fractions.
- Rougher Flotation--Recycled water is used in the rougher flotation circuit to replace water used to pump sand tailings to disposal areas.
- Amine Flotation--Deep well water, which is tannin and particulate free, is required for this critical flotation step to ensure recovery of the product.

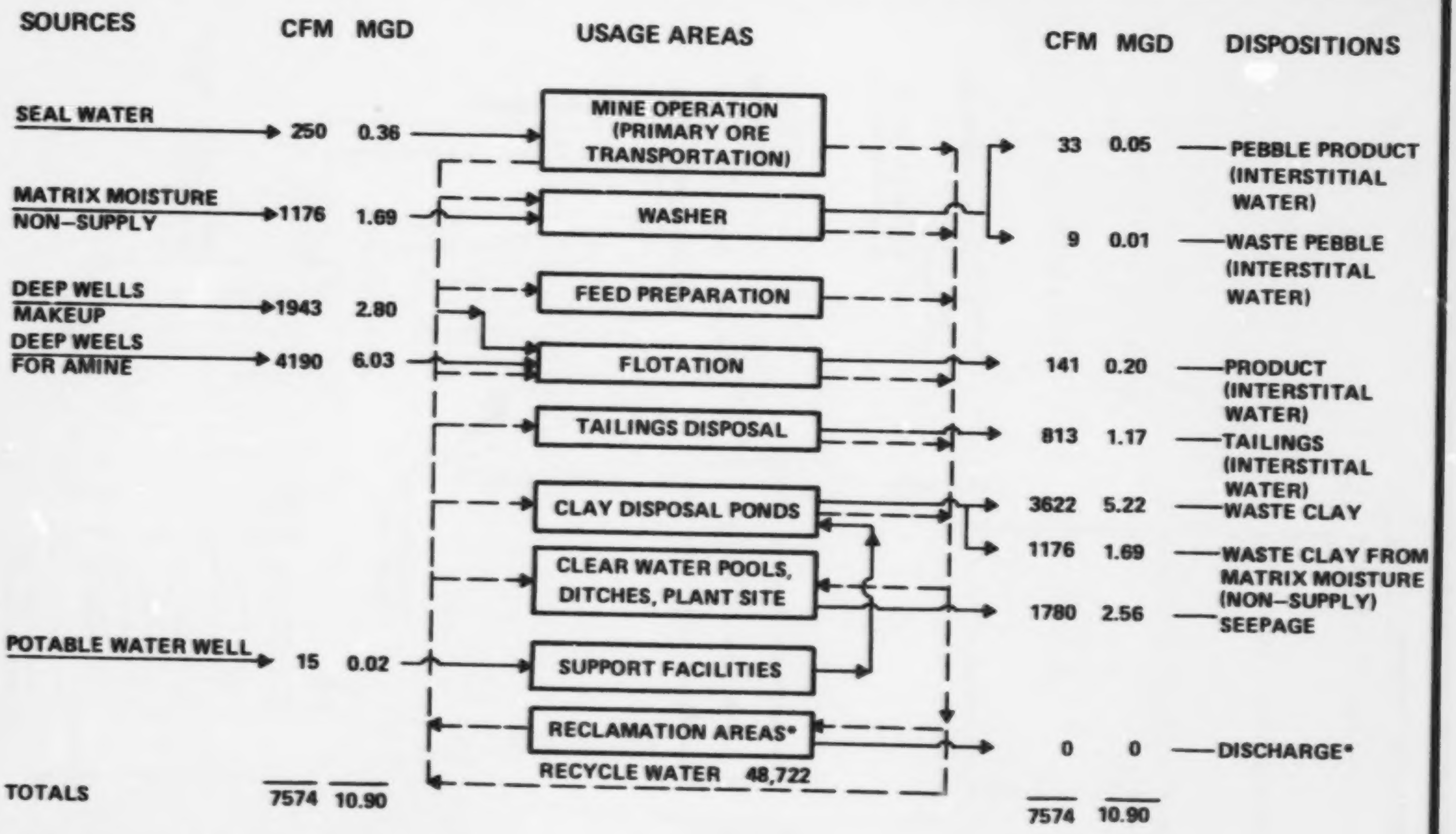
- Waste Disposal--Recycled water and water from the flotation circuits is used as a medium for transporting waste clays and sand tailings from the beneficiation plant to disposal areas.
- Centrifugal Pump Seals--Water from shallow wells is used as sealing water for matrix and tailings pumps.

Figure 2-23 presents the key water uses for the mine as planned by Farmland. The respective sources and final disposition for the water are also presented.

2.5.2 WATER RECIRCULATION SYSTEMS

Water will be recycled to the maximum extent possible. The mine water recirculation system shown in Figure 2-24 consists of Clay Settling Areas I, IIA, and IIB; the clear water pond; beneficiation plant; active and mined-out pits; active sand-clay mix areas, and return-water ditches. The clay settling areas, active sand-clay mix areas, and the return-water ditches act as a water clarification system, returning decanted water to the clear water pond. Clear water is then recirculated to the mine and to the beneficiation plant. The water returns to the recirculation system to be reused many times before being lost to the waste or phosphate products as entrained water. Recirculating water flow is expected to be approximately 50,000 GPM.

The major water loss from the recirculation system is entrainment in the waste clays. It is anticipated that the sand-clay mix procedures will result in less loss of water due to such entrainment. However, the process has not been thoroughly tested; consequently, the degree of success for water recovery is not known at this time. Seepage from pools and ditches represents the second largest water loss from the system. The other losses from the water recirculation system are entrainment of water in the sand tailings, product moisture, and waste pebble interstitial water.


SOURCES
CFM MGD
USAGE AREAS
CFM MGD
DISPOSITIONS
SEAL WATER
250 0.36
MATRIX MOISTURE NON–SUPPLY
1176 1.69
DEEP WELLS MAKEUP
1943 2.80
DEEP WEELS FOR AMINE
4190 6.03
POTABLE WATER WELL
15 0.02
TOTALS
7574 10.90
MINE OPERATION (PRIMARY ORE TRANSPORTATION)
WASHER
FEED PREPARATION
FLOTATION
TAILINGS DISPOSAL
CLAY DISPOSAL PONDS
CLEAR WATER POOLS, DITCHES, PLANT SITE
SUPPORT FACILITIES
RECLAMATION AREAS*
RECYCLE WATER 48,722
33 0.05
PEBBLE PRODUCT (INTERSTITIAL WATER)
9 0.01
WASTE PEBBLE (INTERSTITAL WATER)
141 0.20
PRODUCT (INTERSTITAL WATER)
813 1.17
TAILINGS (INTERSTITAL WATER)
3622 5.22
WASTE CLAY
1176 1.69
WASTE CLAY FROM MATRIX MOISTURE (NON–SUPPLY)
1780 2.56
SEEPAGE
0 0
DISCHARGE*
7574 10.90

* SAND CLAY MIX STARTS IN YEAR 4; RECLAMATION HAS NOT ACTUALLY BEGUN BY YEAR 4. NOTE THAT THE DISCHARGE OF WATER GRADULLY INCREASES AS THE TOTAL CATCHMENT AREA INCREASES DUE TO MINE EXPANSION WITH MAXIMUM OCCURING WHEN MINING AND RECLAMATION ARE AT EQUILIBRIUM IN YEAR 11

** UNCONTAMINATED PROCESS WATER

NOTE: WATER FROM SUPPLY (GROUND WATER) = 13.34 MGD LESS MATRIS WATER (1.69 MGD) AND WET ROCK MOISTURE (0.12 = MGD) =11.53 MGD

FIGURE 2-23. MINE WATER BALANCE UNDER ANNUAL AVERAGE CONDITIONS.

SOURCE: FARMLAND INDUSTRIES, INC.

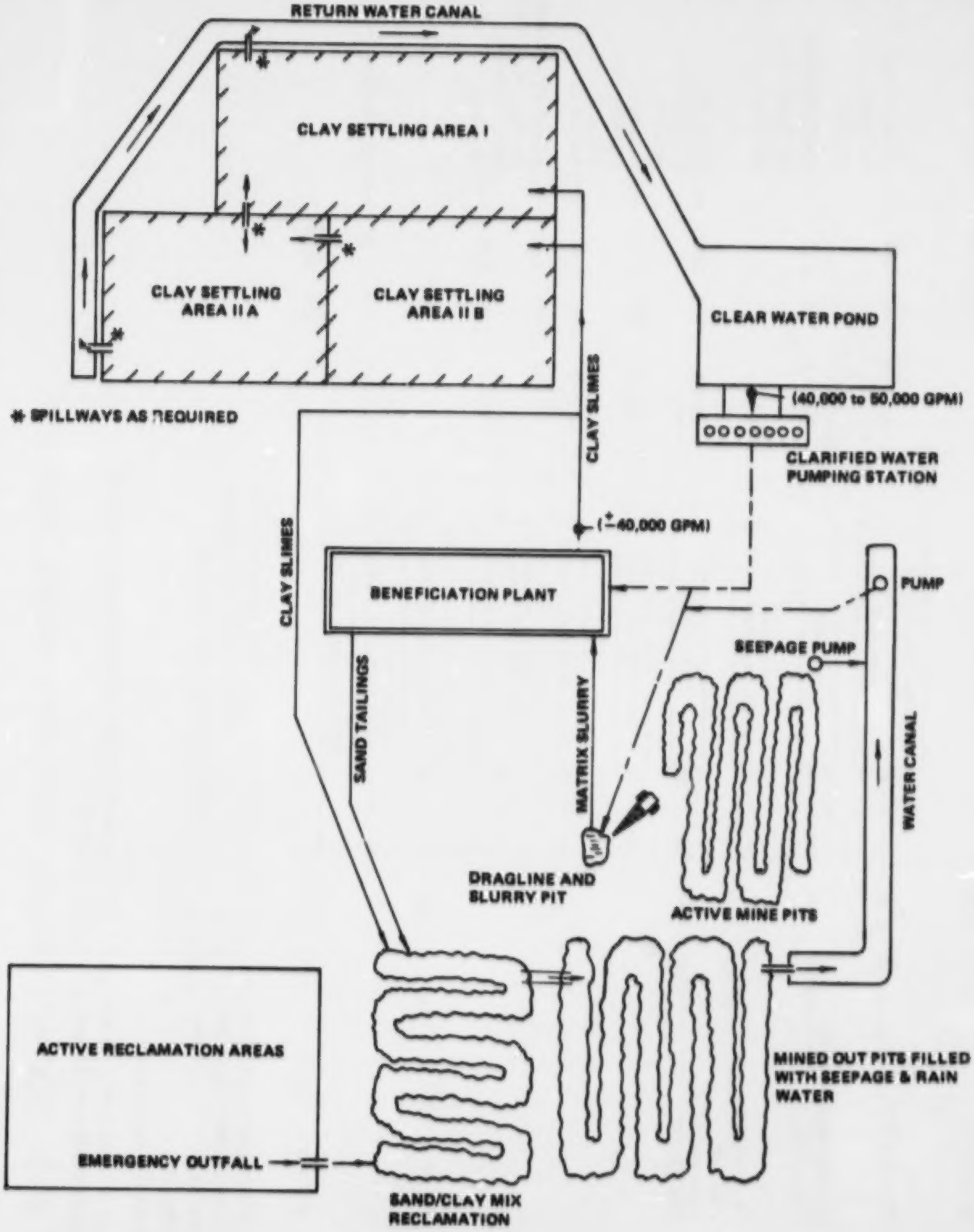

RETURN WATER CANAL
CLAY SETTLING AREA I
CLAY SETTLING AREA II A
CLAY SETTLING AREA II B
CLEAR WATER POND
* SPILLWAYS AS REQUIRED
CLAY SLIMES
(40,000 to 50,000 GPM)
CLARIFIED WATER PUMPING STATION
(±40,000 GPM)
BENEFICIATION PLANT
PUMP
SEEPAGE PUMP
CLAY SLIMES
SAND TAILINGS
MATRIX SLURRY
WATER CANAL
DRAGLINE AND SLURRY PIT
ACTIVE MINE PITS
ACTIVE RECLAMATION AREAS
MINED OUT PITS FILLED WITH SEEPAGE & RAIN WATER
EMERGENCY OUTFALL
SAND/CLAY MIX RECLAMATION

FIGURE 2-24. ELEMENTS OF MINING-WASTE DISPOSAL RECIRCULATION SYSTEM.

SOURCE: J.J. CAPE, OCTOBER 1979.

Table 2-5 lists the various chemicals or solids which will enter the water recirculation system, and their respective dilution ratios. The reagent ratio of dilution in the wastewater is as if it were to pass through the beneficiation process without chemically reacting.

The mining and beneficiation operations operate with fixed water usage for any given production rate. During the dry season it will be necessary to use well water as makeup to balance the system. However, during the rainy season, the accumulation of rainfall and runoff in the system may actually exceed the storage capacity and discharges will be necessary. During such times no makeup well water will be required.

Seasonal changes in rainfall and evaporation rates will also affect the active water volume of the mine recirculating water system. During the pre-filling of Settling Area I and the initial years of mining the rainfall in excess of evaporation during the rainy season will provide additions to the system and help offset system losses. Conversely, during dry periods the deficit due to evaporation will add to the system losses. The system's volume will aid in leveling out these seasonal changes.

Seasonal changes in rainfall and evaporation do not have a direct effect on the water required to operate the mine system, since the demands remain reasonably constant, with variations due mainly to mining rates and clay content of the ore. Seasonal deficits in the mine water system can occur, however, due to:

- insufficient reservoir capacity to accumulate rainfall during the wet season to offset evaporation losses during the dry season
- insufficient catchment area to offset the deficit between rainfall and evaporation rates

The normal rainfall in the vicinity of the Farmland site is about 55 inches per year (Figure 2-25). The mine system is designed to provide sufficient catchment area and water storage volume to level out seasonal fluctuations in supply by rainfall/evaporation and to prevent variations in groundwater withdrawal rates, especially the need for increased groundwater withdrawal during the dry season. The water balance diagram (see Figure 2-26) shows the average annual rainfall/evaporation with expected active mining and reclamation areas being used for catchment to offset annual rainfall/evaporation deficits. These deficits average about 10 inches per year in the ponds and pools of the main plant and the mine water system (see Figure 2-27). For the average annual rainfall/evaporation conditions, the 10-inch deficit in the main water system will be offset by collection in the mining and reclamation areas (0.62 mgd). Excess accumulation will occur as the total catchment area increases, resulting in a gradual increase in the amount of water discharged.

2.5.3 GROUNDWATER WITHDRAWALS

Groundwater withdrawal is necessary to compensate for water losses from the recirculation system and to provide suitable water for the amine flotation circuit. Small scale withdrawal from shallow wells is also required to provide sealing water for matrix and tailings pumps. Based upon conventional clay settling methods, the average daily groundwater withdrawal requirement for the mine area process use has been calculated to be 9.21 mgd (Table 2-6). Not all of this requirement is regarded as consumptive use since most of the seepage losses and a portion of the water entrained in clays, product, waste pebble, and sand tailings seep back into the Surficial Aquifer (Table 2-7). Taking credit for water seepage, the net withdrawal for the mine area is approximately 4.77 mgd, or 52 percent of the total groundwater withdrawal rate.

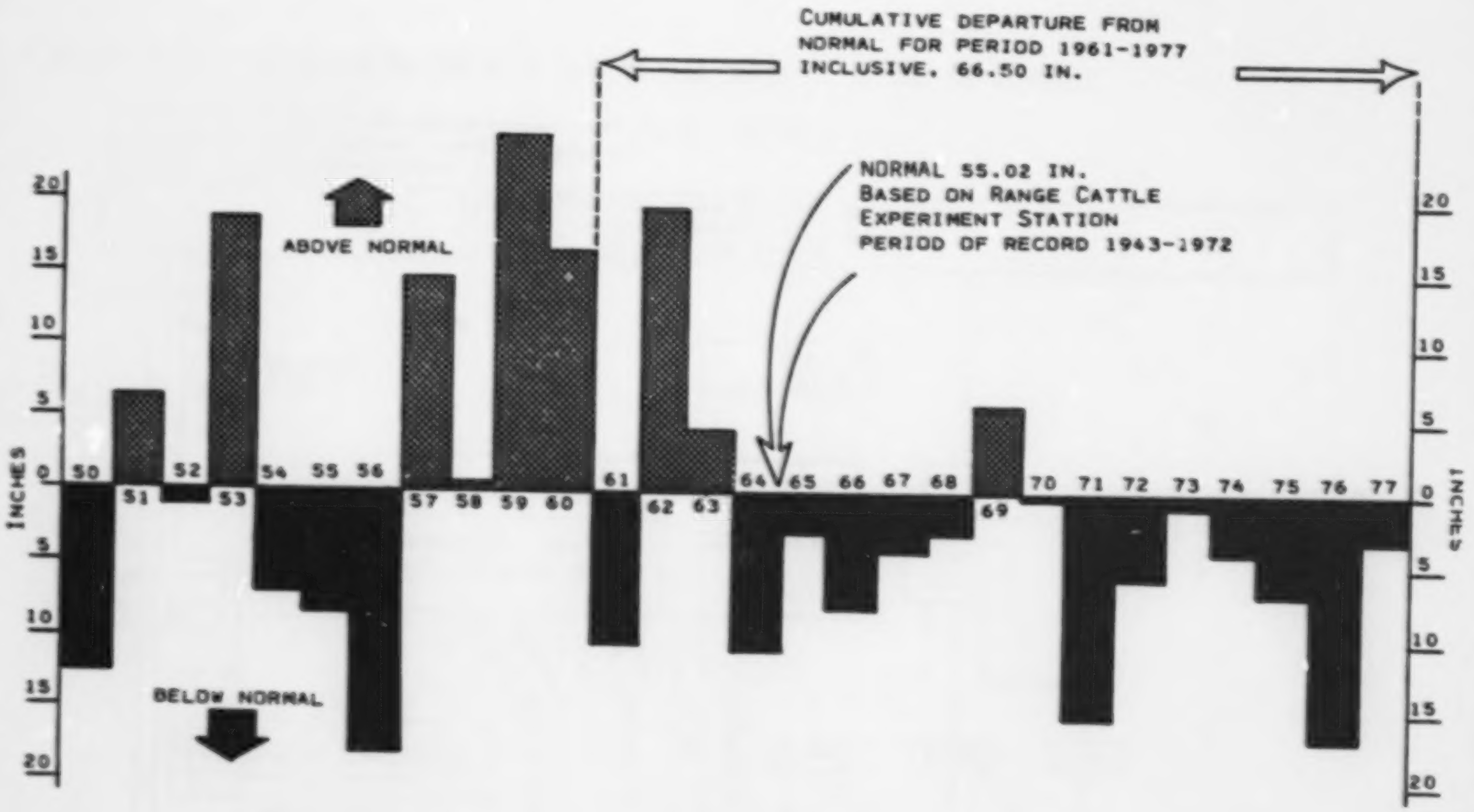
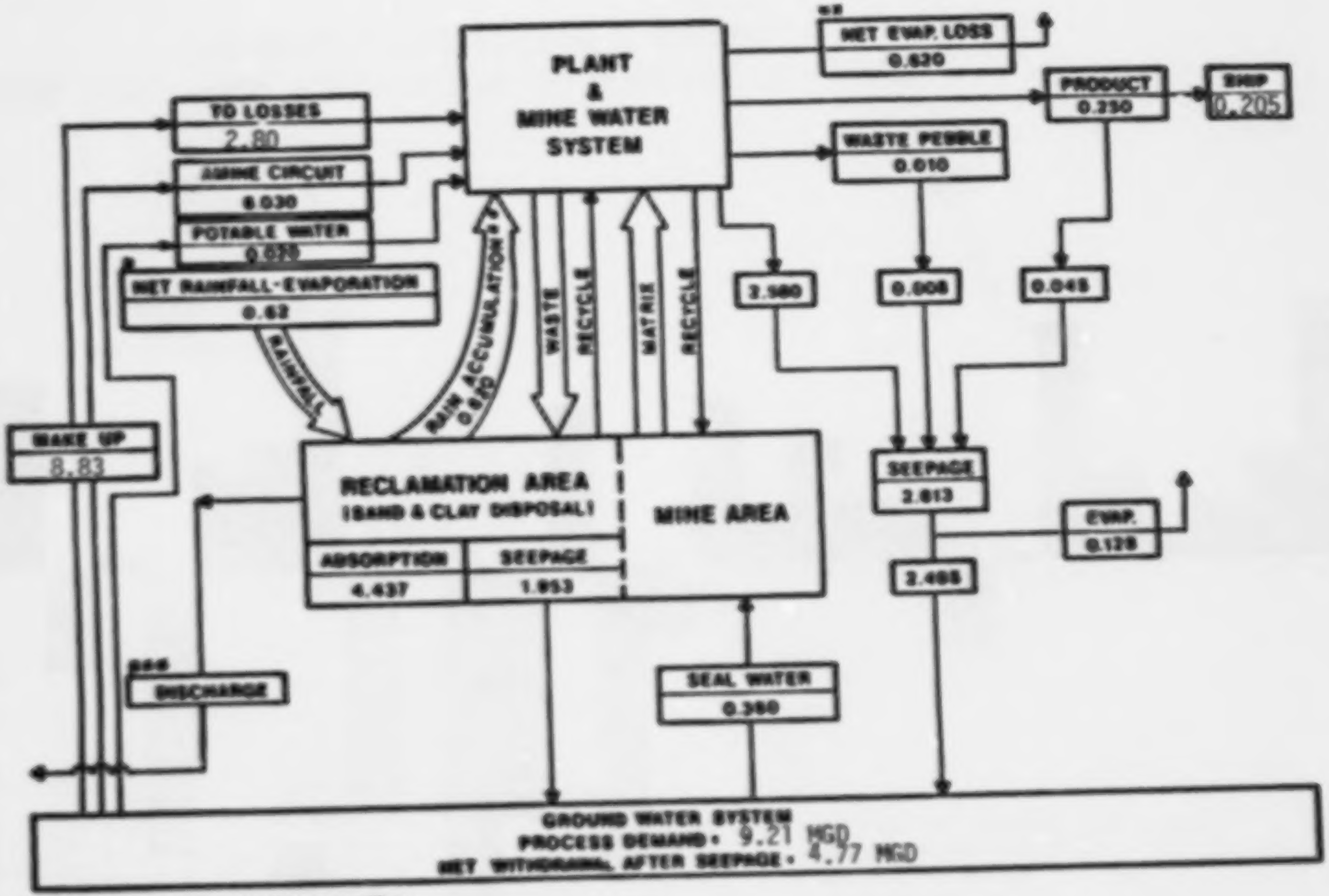


FIGURE 2-25. TOTAL PRECIPITATION AND DEPARTURE FROM NORMAL FOR RANGE CATTLE EXPERIMENT STATION.

SOURCE: FARMLAND INDUSTRIES, INC., DRI, JUNE 1979

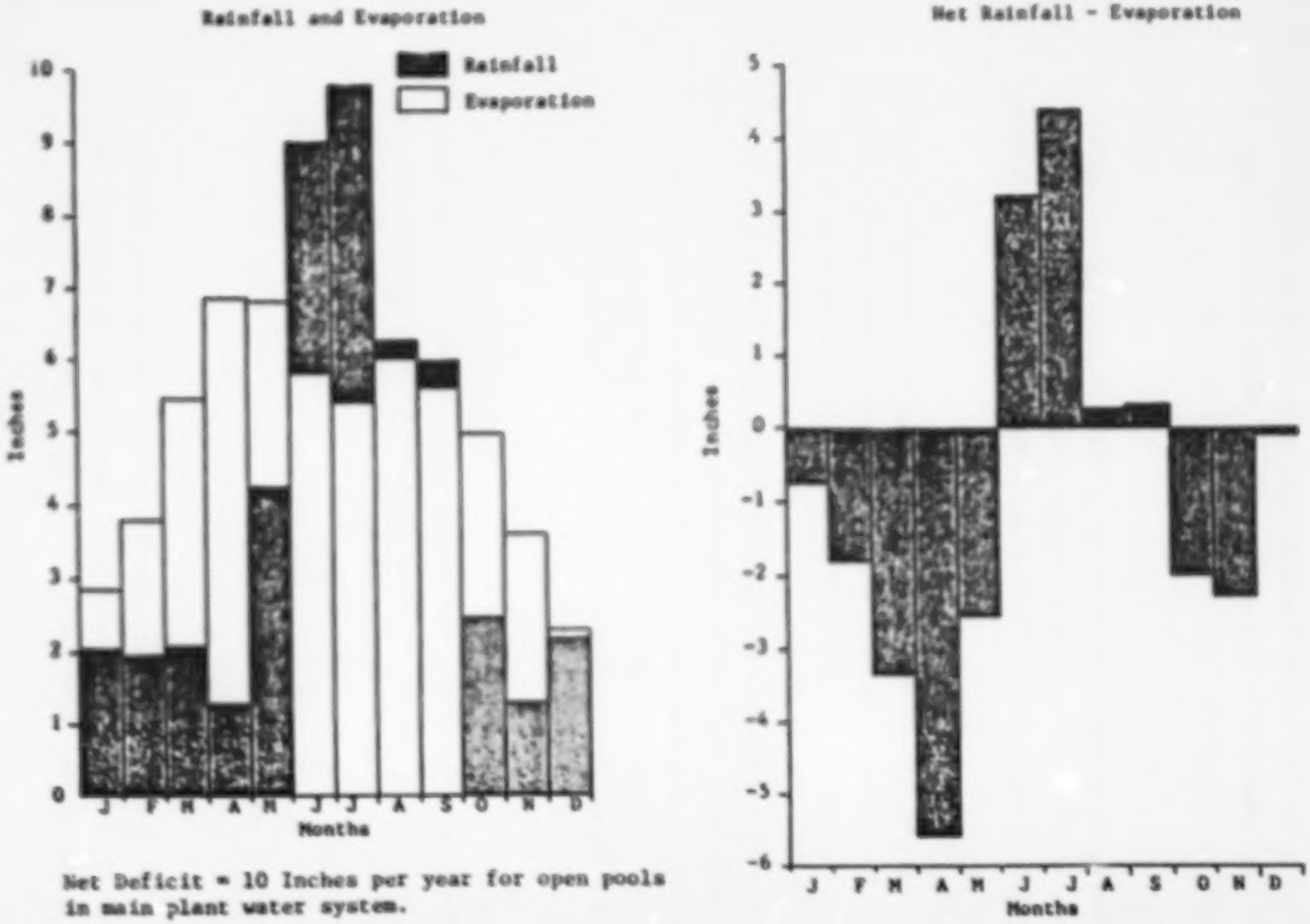


PLANT & MINE WATER SYSTEM
TO LOSSES 2.80
AMINE CIRCUIT 0.030
POTABLE WATER 0.020
* NET RAINFALL-EVAPORATION 0.62
RAINFALL
RAIN ACCUMULATION** 0.620
WASTE
RECYCLE
MATRIX
RECYCLE
** NET EVAP. LOSS 0.620
PRODUCT 0.250
SHIP 0.205
WASTE PEBBLE 0.010
2.580
0.008
0.045
SEEPAGE 2.613
EVAP. 0.128
2.485
MAKE UP 8.83
RECLAMATION AREA (SAND & CLAY DISPOSAL)
ABSORPTION 4.437
SEEPAGE 1.953
MINE AREA
*** DISCHARGE
SEAL WATER 0.360
GROUND WATER SYSTEM
PROCESS DEMAND • 9.21 MGD
NET WITHDRAWAL AFTER SEEPAGE • 4.77 MGD

*Based on normal rainfall-evaporation.
**Accumulation affects mine water system evaporation loss.
***Excess accumulation is discharged as catchment area increases in later years.

FIGURE 2-26. MINE WATER BALANCE DURING THE INITIAL YEARS OF MINING.

SOURCE: FARMLAND INDUSTRIES, INC., DRI, JUNE 1979



Net Deficit = 10 Inches per year for open pools in main plant water system.

FIGURE 2-27. ANNUAL RAINFALL AND EVAPORATION AT THE FARMLAND SITE.

SOURCE: FARMLAND INDUSTRIES, INC., DRI, JUNE 1979

During the life of the Farmland mine the non-potable water withdrawal requirements will vary substantially. These variations can generally be categorized into the following four phases:

Phase I

The existing water demand on the property is 6.96 mgd maximum or 1.72 mgd average. This is an irrigation demand and occurs during the dry season of the year, a period of approximately three to four months.

Phase II

Pre-mining water demand is the requirement for pre-filling Settling Area I. The pre-filling is necessary to offset delayed water release by clays on startup of the mining operation. Water continues to be released by the clays at the completion of mining, so that this water will eventually be recovered. The quantity of water for pre-filling is based on a maximum deep well rate of approximately 8.93 mgd for 365 days. The water level in Settling Area I will be maintained at an elevation sufficient to provide rapid flow return to the plant water pool upon startup. The irrigation demand will be discontinued when this filling begins.

Phase III

The third phase covers the startup years, or period of greatest water retention by the waste clays, based on conventional clay disposal with solids reaching 17 percent and smaller catchment areas than will exist in the later years of mining. The quantity of deep well water required is 8.85 mgd. This includes 8.83 mgd for rock processing and 0.02 mgd for potable water.

Phase IV

During the fourth phase, the planned sand-clay mix treatment is expected to reduce the deep well water requirements by returning more water to the system due to increased solidification of the clays.

Experimentation with the procedure will begin early in the project to insure that the process will be developed and in routine use at an early date. The degree of success for water recovery improvement is not known at this time; therefore, the estimated groundwater demand is shown only as a quantity equal to or less than that required during conventional clay disposal (Phase III).

2.5.4 PRODUCTION WELLS

The production wells will be drilled to a depth of about 1400 feet (Avon Park Limestone*). About 8.83 mgd of deep well water will be withdrawn from these wells. These will be located in the vicinity of the beneficiation plant such that the predicted drawdown impact at the Farmland property line will not exceed the limits established by the Southwest Florida Water Management District.

A potable water well will also be drilled at the site. About 0.02 mgd will be withdrawn from the Floridan Aquifer.

2.5.5 OTHER WELLS

In addition to the well fields at the beneficiation plant, five wells having a cumulative capacity of 0.36 mgd will be developed in the Surficial Aquifer* to provide sealing water for matrix and tailings pumps.

2.5.6 MAXIMUM WELL PUMPAGE

The maximum pumpage which is presently planned at the mine site will occur during the prefilling of settling ponds when mine well M-1 will be pumped at maximum capacity (6200 gpm). Filling of the settling

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*See relative depths and water aquifers in Figure 2-28, Hydrogeologic Cross Section.

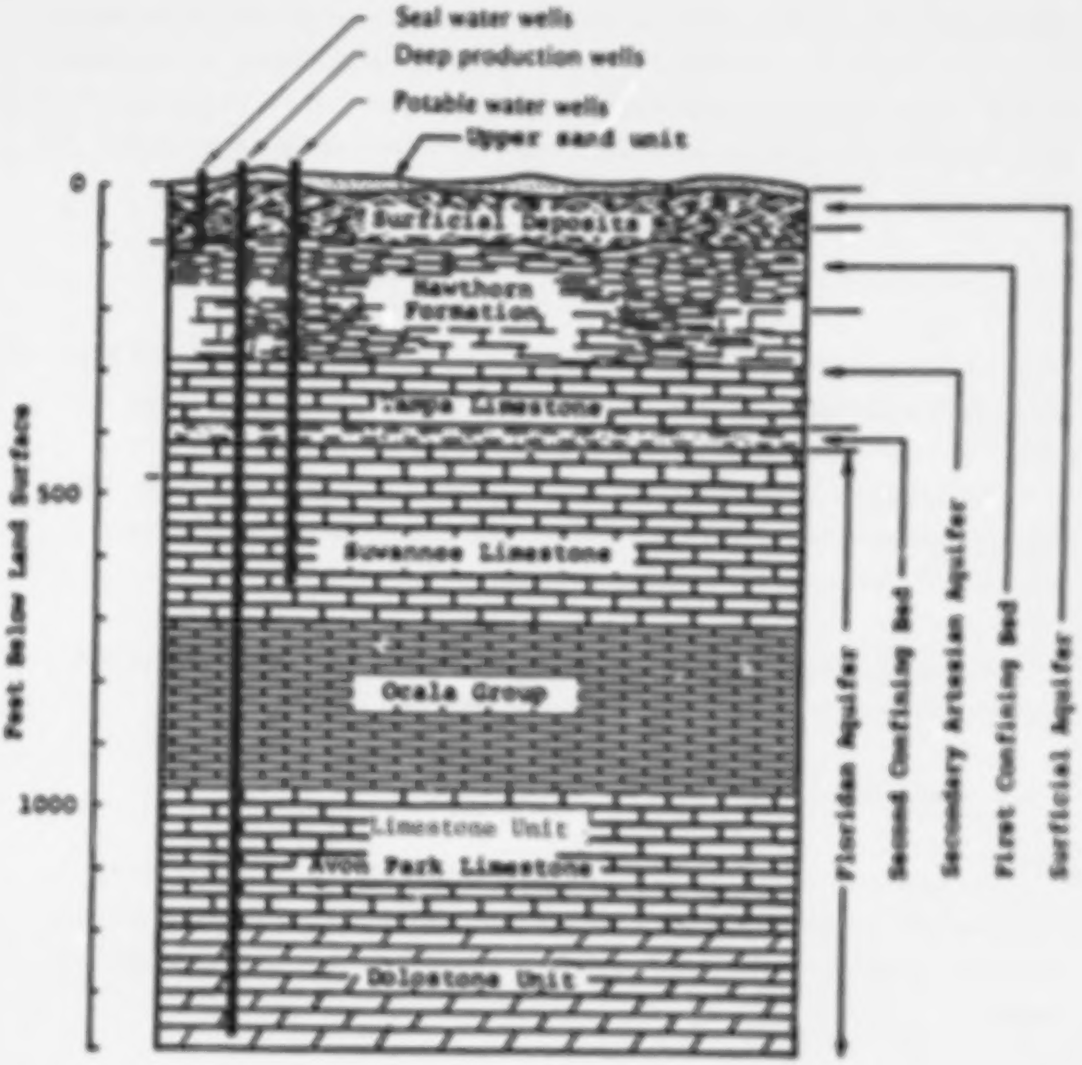
Seal water wells
Deep production wells
Potable water wells
Upper sand unit
Surficial Deposits
Hawthorn Formation
Tampa Limestone
Suwannee Limestone
Ocala Group
Limestone Unit
Avon Park Limestone
Dolostone Unit
Feet Below Land Surface
0
500
1000
Floridan Aquifer
Second Confining Bed
Secondary Artesian Aquifer
First Confining Bed
Surficial Aquifer

FIGURE 2-28 WELL LOCATIONS WITHIN THE FARMLAND SITE HYDROGEOLOGICAL CROSS SECTION.

SOURCE: FARMLAND INDUSTRIES, INC., DRI, JUNE 1979

ponds on the mine site (with no allowance for rainfall additions) will require pumping for 380 days at this rate. The actual length of the prefilling period will vary, however, because of the potential need to reduce the pumping rate during dry periods (in order to conform with SWFWMD regulations.

2.5.7 MINE PIT DEWATERING

Dewatering of active mine pits is considered necessary to insure efficient recovery of phosphate ore. It is estimated that pumping at a rate of 500 gpm will be required in order to keep water at an acceptable level. Should normal pumping from the pit not reduce the water level sufficiently, additional methods will be utilized. One method utilizes the dragline to place a soil plug against the sidewall to reduce flow. Another method uses the dragline to place cast spoil downstream of the seepage point to contain the water in an impoundment area. In extreme cases a backup wellpoint system may be required near the face of the cut. Groundwater would be pumped to the surface until the breakout velocity is decreased below the erosional level. Complete dewatering is probably not attainable with this system, but its effectiveness in eliminating uncontrolled erosion makes it a viable option in most situations.

Mining and engineering techniques will be used to minimize or eliminate any adverse drawdown effects. For example, mine cuts adjacent to property boundaries will be backfilled soon after matrix removal is completed. Where necessary, rim ditches will be constructed between open mine pits and property boundaries and the water level in the ditch held at an adequate level to maintain the existing water table elevation.

When mining is complete, mine pits will be hydraulically backfilled with clay, sand, or sand-clay wastes except in a few cases in which lakes are planned. The water used to transport these wastes will reestablish the surface water table in the pits. In most cases, backfilling of mine pits is planned for the year following mining; therefore, the water table will be reestablished in a relatively short period of time.

2.5.8 SURFACE WATER RUNOFF

During mining, the water recirculation system (including the active waste disposal areas, the clear water pond, and the recirculation ditches) will capture a portion of the rainfall that formerly ran off into the onsite stream courses. Maximum collection of rainfall in the mine water system will occur by year 15, which will represent a maximum reduction of runoff from the site during mining. By year 15, approximately 2684 acres will be removed from natural drainage, and most of the rain falling within this area will be captured into the recirculating system. The reduction in streamflow from natural drainage will be about 5 cfs at this time; however, 3 cfs will be returned to the stream as stormwater discharge so that the net total streamflow reduction will be about 2 cfs. The average reduction in streamflow will be somewhat less than this maximum value.

The water discharged to each stream on the site is a function of the soil permeability, land gradient, vegetative cover, and drainage area, and presently occurs (with the exception of the Peace River) almost entirely in response to rainfall events. Farmland's reclamation plans call for the reconstruction of the drainage areas of each stream on the mining tract to approximately their pre-mining size. The surface storage capacity on the property will be increased by the lakes and marshes created by reclamation. Under average conditions, the net effect is expected to be a small decrease (-0.5 cfs) in average streamflow. A complete description of the drainage system throughout the life of the mine would be extremely detailed. For the purpose of illustration, some of the major components during the operating and post-operating phases are explained in this section and are shown on Figure 2-29.

FIGURE 2-29.
MASTER DRAINAGE PLAN
FOR THE MINE SITE.
(SEE INSIDE BACK COVER)

The water balance planned for the Farmland project uses retention capacity and recirculation efficiency to determine the makeup water needs of the development. The design of the recirculating water system (Figure 2-30) allows for the segregation of process recirculation water within the system from the overland flow outside of the system. Settling Areas I, IIA, and IIB will be designed to contain a 25-year storm rainfall event (defined as having 9.63 inches of rainfall in a 24-hour period) and release 12 inches of water in a 24-hour period. The size of each area predicates a minimum number and size of release structures. The preliminary locations of these spillways are shown in Figure 2-29. This figure also shows an example of the recirculation system as it should appear during mining year 9, after the activation of the Settling Area IIB. After year 6, the waste disposal system has maximum flexibility. Flow lines are indicated from the pumping station located at the southeast corner of Settling Area IIB, which will pump waste clays from the washer into the settling area. The ability to circulate the westward flow will be provided by a spillway structure through a common dike between Settling Areas IIA and I. This will enable fluid to flow either into Settling Area I (and reenter the system), or be decanted into the natural drainage system during periods of excess rainfall by a spillway structure on the west side of Settling Area IIA. Recirculated water will pass through Settling Area I, into the recirculation canal along the northern and eastern boundaries of Area I, and then into the clear water pool for recirculation to the plant.

2.5.9 WATER DISCHARGE

The water discharge points for the mining and beneficiation operation are shown in Figures 2-29 and 2-30. The primary plant discharge, identified as Ⓐ in Figure 2-29, will be the discharge of clarified water from the clear water pool into Hickory Creek. A second discharge point, identified as Ⓑ in Figure 2-29, will be used only occasionally to discharge water from Settling Area IIA into Oak Creek. A third

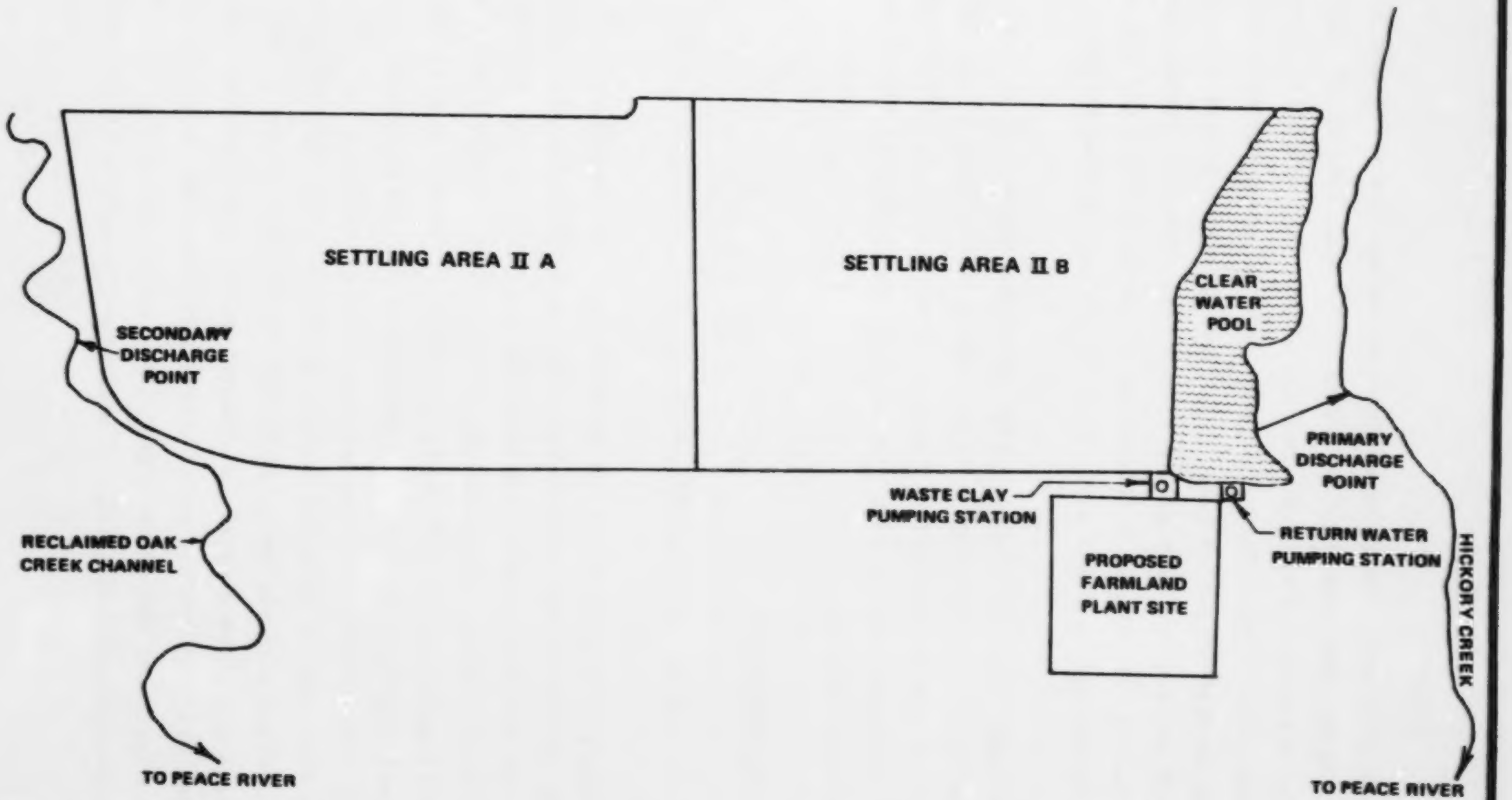
SETTLING AREA II A
SETTLING AREA II B
CLEAR WATER POOL
SECONDARY DISCHARGE POINT
PRIMARY DISCHARGE POINT
WASTE CLAY PUMPING STATION
RETURN WATER PUMPING STATION
PROPOSED FARMLAND PLANT SITE
RECLAIMED OAK CREEK CHANNEL
HICKORY CREEK
TO PEACE RIVER
TO PEACE RIVER

FIGURE 2-30. PRIMARY AND SECONDARY DISCHARGE POINTS.

SOURCE: FARMLAND INDUSTRIES, INC., DRI, JUNE 1979

discharge point will change as mining and reclamation areas change. This discharge (not specified in Figure 2-29) will consist of runoff from land areas that are in the process of settling and being revegetated for reclamation. This water will be discharged directly into the adjacent natural stream system. All three discharge points will be monitored as required by regulatory agencies. However, should the water become turbid, it will be recirculated to the settling areas and eventually discharged as clean water from the primary discharge point.

Effluent from the onsite sewage treatment plant will be routed into the mine water recirculation system. The dilution rate of the treated effluent in the recirculation system will be 4800 to 1. Discharges of diluted effluent will be made only through the discharge points for the recirculation system.

2.6 LAND RECLAMATION

2.6.1 END USE OF THE RECLAIMED SITE

Figure 2-31 shows both the existing land use breakdown for the site and the percent of the various land use classifications after reclamation is complete. Table 2-9 lists the acreages for the specific land use classifications. Economic use of the post-reclamation site will be primarily agricultural just as it is today. Although most of the reclaimed land will be initially planted as improved pasture, a majority of this land actually will be multipurpose agricultural land (with forage plantings as only the initial ground cover). Certain portions of the reclaimed site may be suitable for citrus, but no commercial citrus plantings are planned until the results of the experimental revegetation program, which includes a trial citrus planting, can be evaluated. The best agricultural use of reclaimed land, particularly the fertile clay and sand-clay landfills, will be determined by actual field experience.

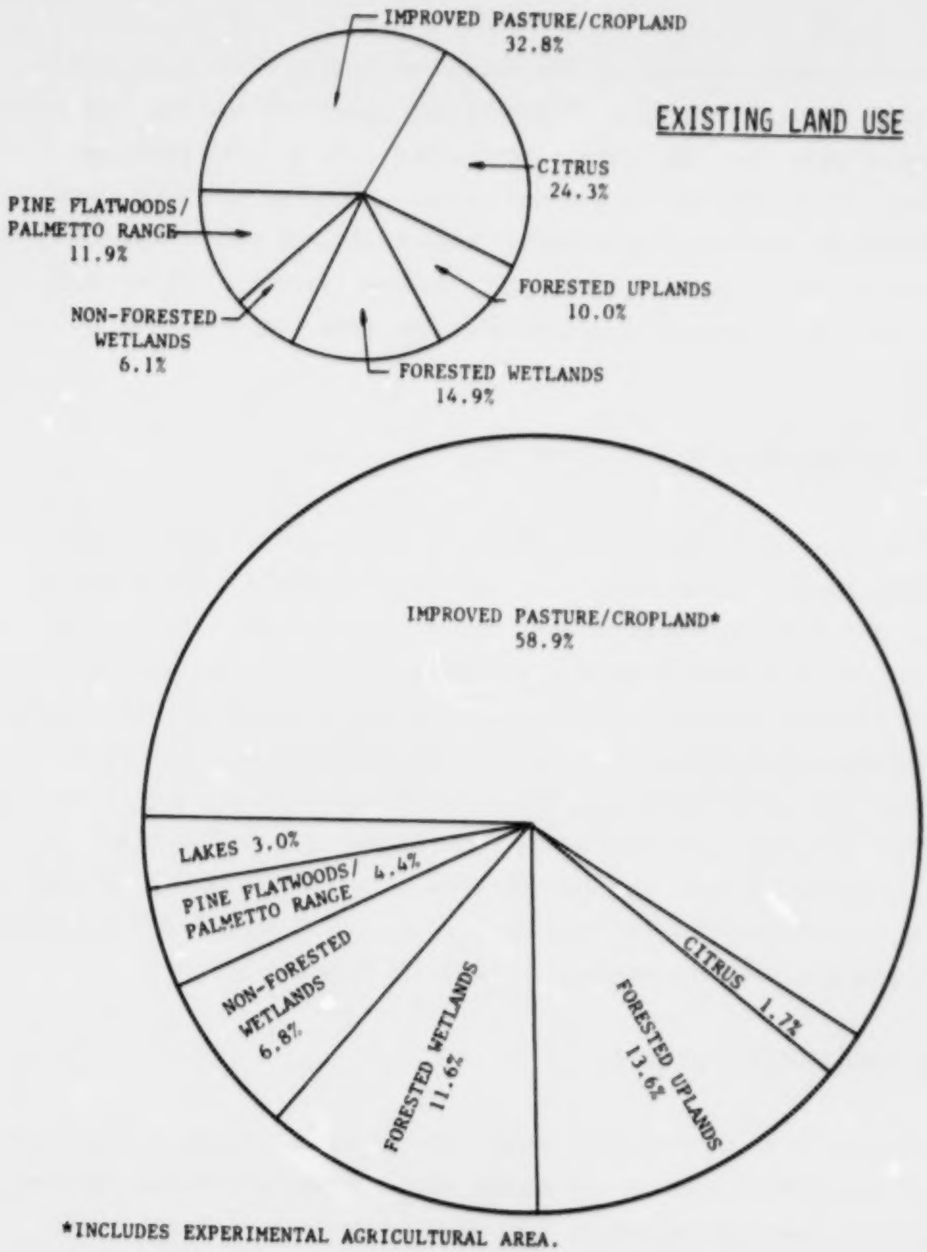

FIGURE 2-31. EXISTING AND POST-RECLAMATION LAND USE ON THE MINE SITE.

SOURCE: FARMLAND INDUSTRIES, INC., HARDEE COUNTY MASTER PLAN, JUNE 1979

A substantial portion of the reclaimed land will have potential uses other than agriculture. The tailings landfills and the land areas associated with the large lake system along S.R. 64 will have been reclaimed to provide sufficient structural stability for most types of construction. Natural ground areas, both reclaimed and undisturbed, are expected to have essentially the same land use potential as existed before mining. Figure 2-32 illustrates the site post reclamation land use.

2.6.2 TOPOGRAPHY OF THE RECLAIMED SITE

The goal of the reclamation plan is to return the land to a state that will readily blend into the natural surroundings. After reclamation, the drainage areas of each stream will be approximately the same size as they were before mining, and the final elevations of the land surface will be only two or three feet above the original. In general the reclaimed areas will be of flatter terrain than in the premining condition, but there will be a slight grade for rainfall runoff into the streams. All dikes and ditches will be graded to acceptable slopes prior to revegetation. The overall view of the final reclaimed area will be one of low relief, consisting of a series of undulating plateaus gently grading into one another (Figures 2-33 and 2-34).

2.6.3 RECLAMATION SEQUENCE

Figures 2-35 through 2-40 depict the proposed reclamation sequence for all disturbed lands on the mining tract. Like all mining developments, reclamation initially lags several years behind the mining schedule because of the time requirements for filling mining cuts with waste materials, subsidence of backfilled areas, grading of spoils to approved slopes, and revegetation. For example, filling of sand-clay landfills takes from 1 to 2 years. For planning purposes, 2 years has been allotted for subsidence and consolidation of these landfills, and

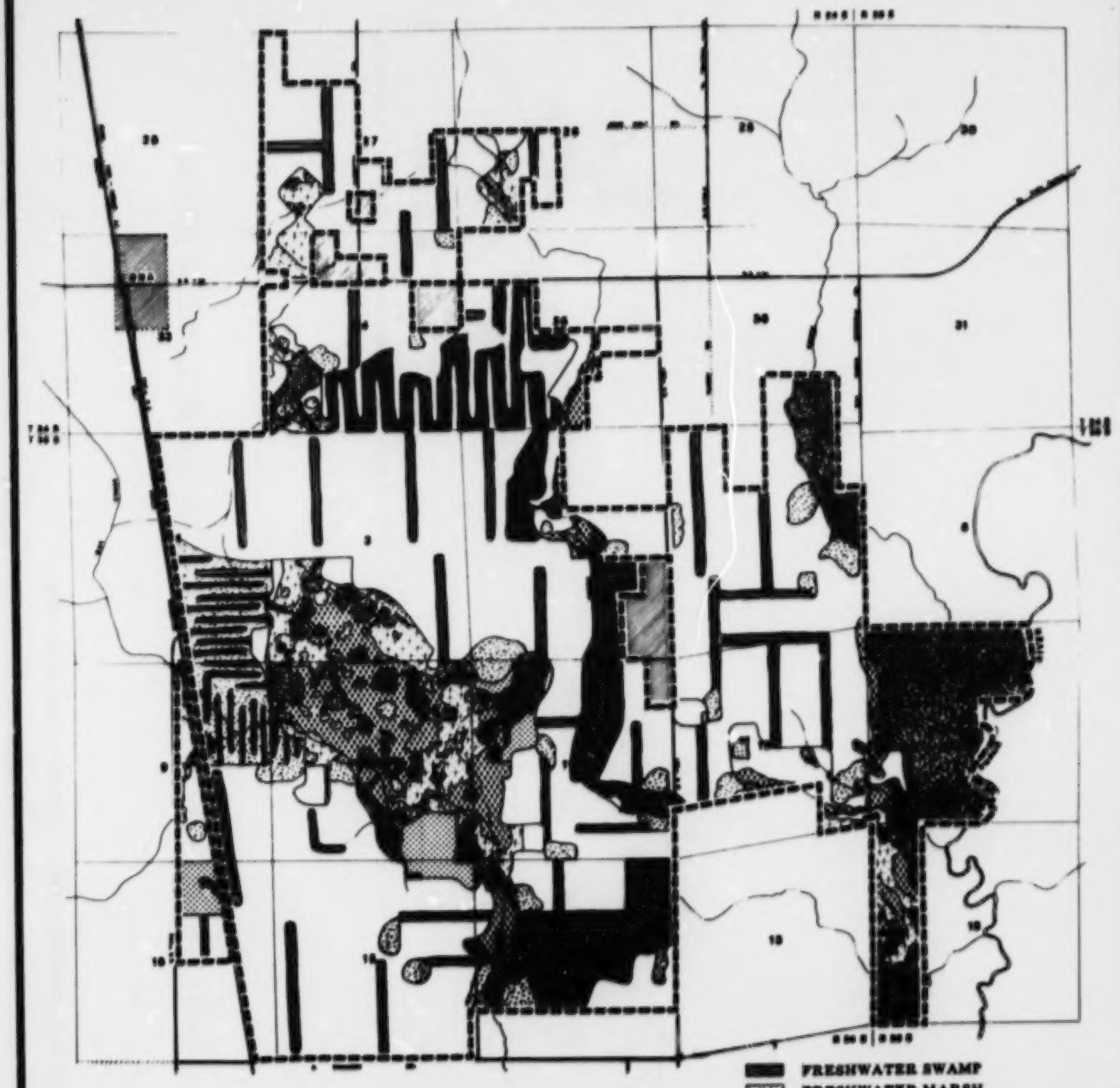
FRESHWATER SWAMP
FRESHWATER MARSH
PINE FLATWOODS/PALMETTO RANGE
UPLAND FOREST
IMPROVED PASTURE
CITRUS
OTHER AGRICULTURE
REFORESTATION WITH MIXTURE OF PINES AND HARDWOODS
LAKE AREAS
N
0
2,000
4,000
SCALE IN FEET

FIGURE 2-32. POST-RECLAMATION LAND USE ON THE MINE SITE.

SOURCE: FARMLAND INDUSTRIES, INC., DRI, JUNE 1979

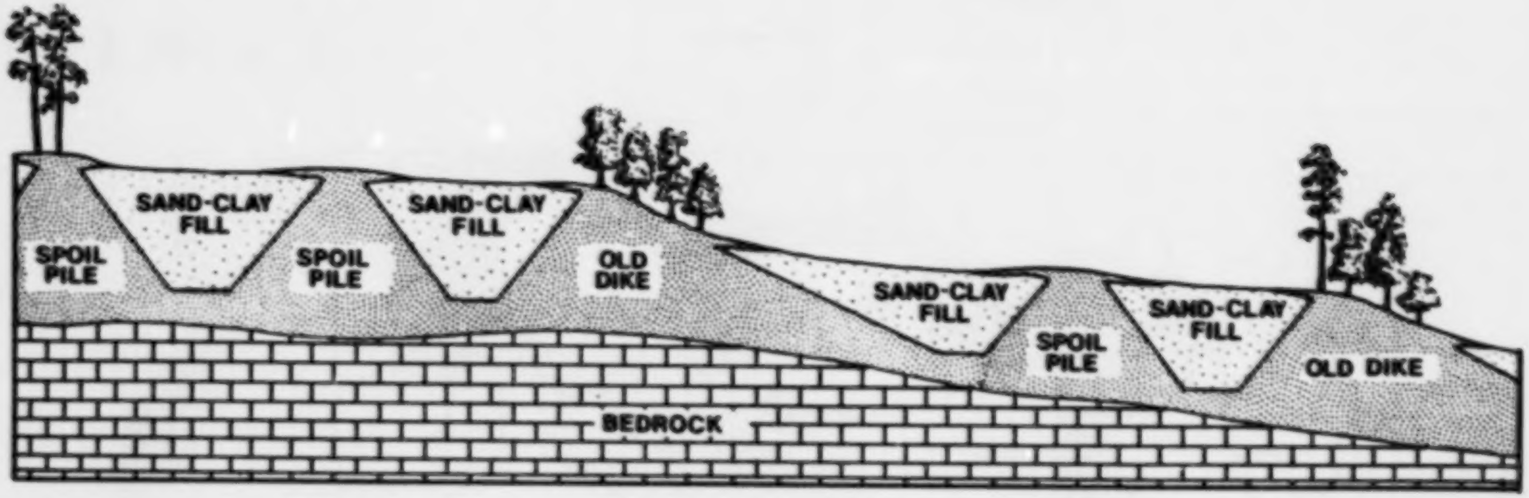
SPOIL PILE
SAND-CLAY FILL
SPOIL PILE
SAND-CLAY FILL
OLD DIKE
SAND-CLAY FILL
SPOIL PILE
SAND-CLAY FILL
OLD DIKE
BEDROCK

FIGURE 2-33. CROSS-SECTIONAL VIEW OF ADJOINING SAND-CLAY MIX RECLAMATION AREAS.

SOURCE: FARMLAND INDUSTRIES, INC., HARDEE COUNTY MASTER PLAN, JUNE 1979

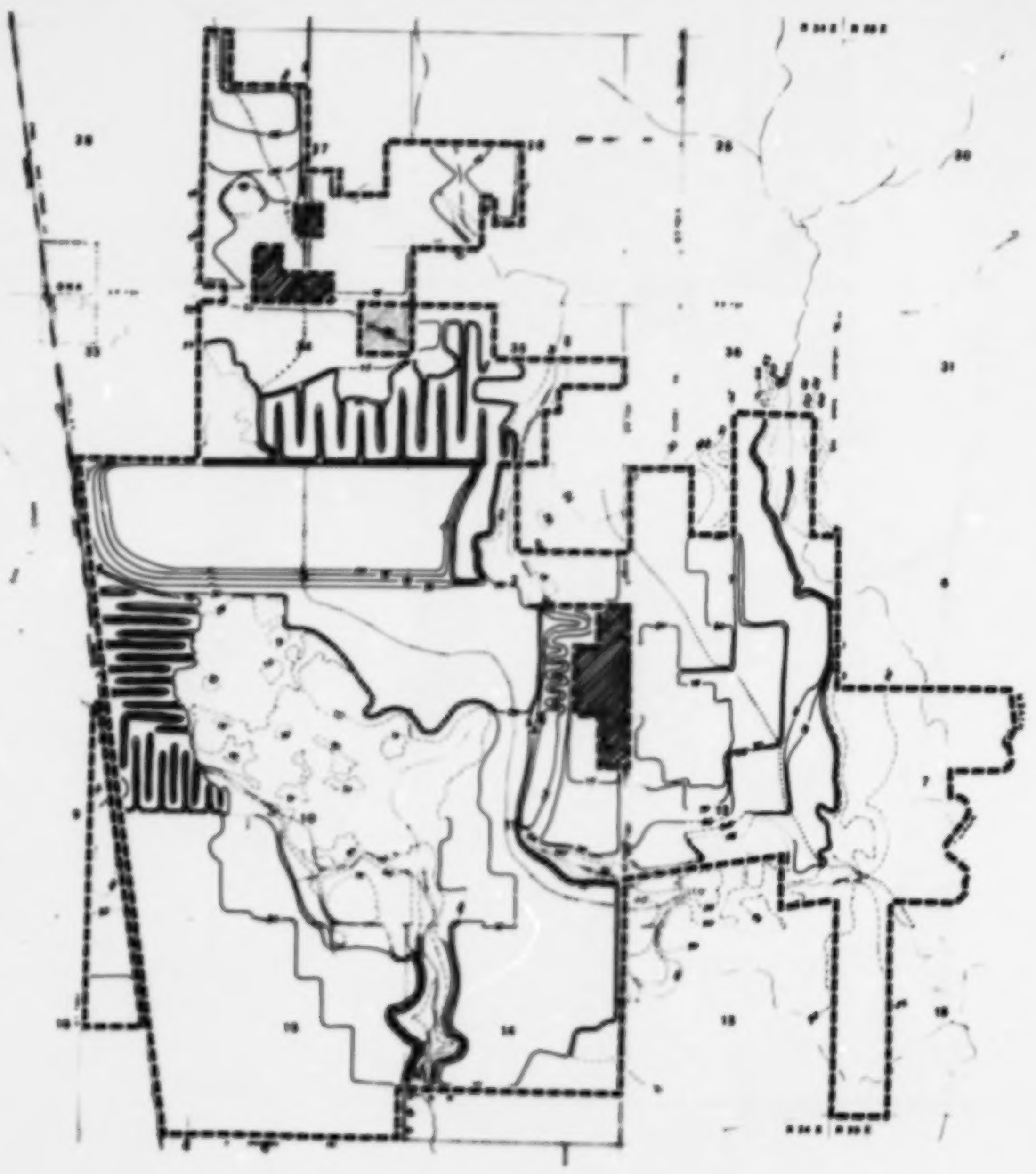
OUT PARCEL (NOT FARMLAND PROPERTY)
EXISTING CONTOUR (M.L. DATUM)
POST-RECLAMATION CONTOUR (MSL DATUM)
DRAINAGE AREA DIVIDE
N
0
2,000
4,000
SCALE IN FEET

FIGURE 2-34. TOPOGRAPHY OF THE MINE SITE FOLLOWING RECLAMATION.

SOURCE: FARMLAND INDUSTRIES, INC., DRI, JUNE 1979

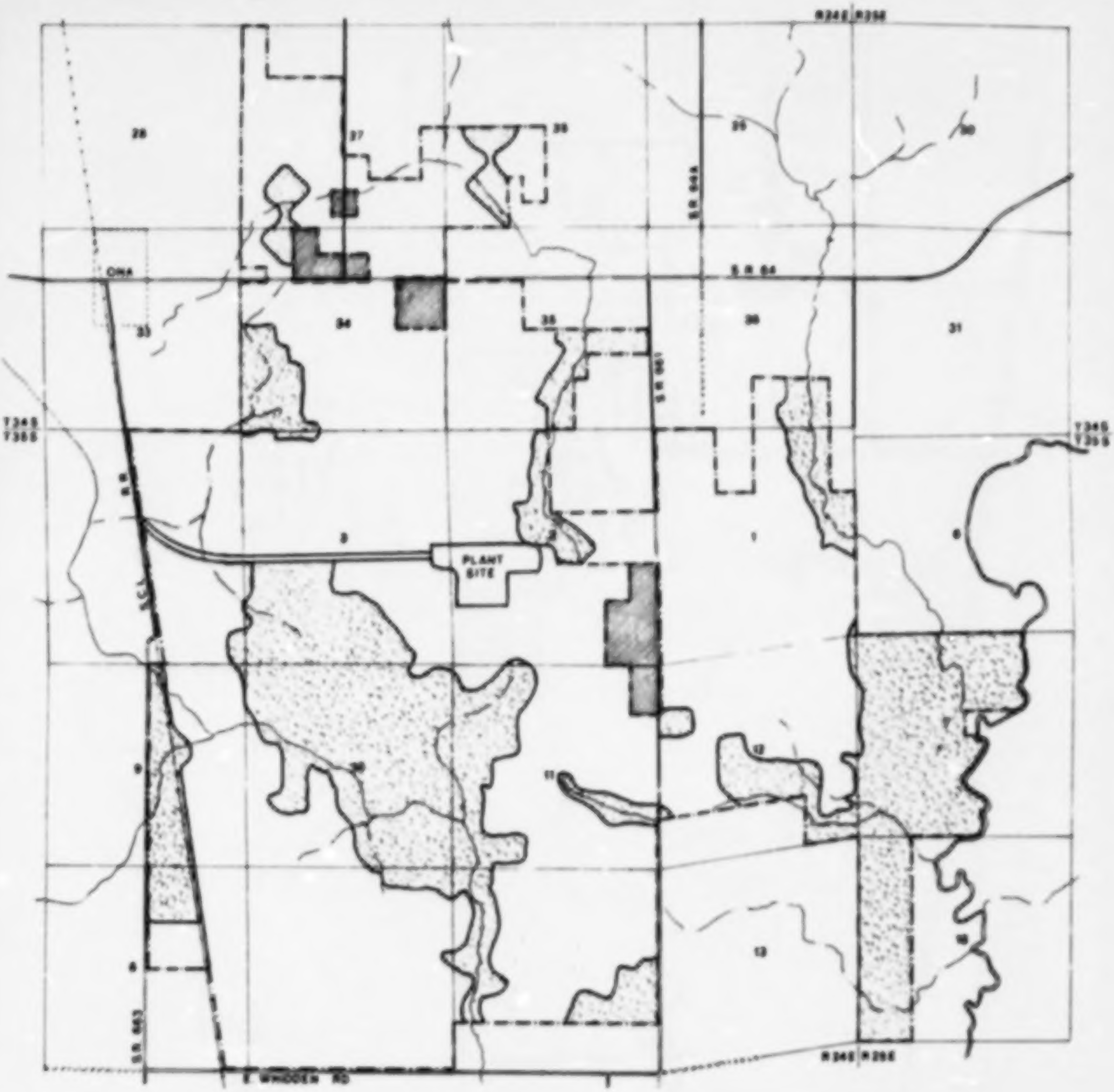
R24E | R25E
28
27
26
25
30
ONA
S.R. 64
S.R. 64A
33
34
35
36
31
T34S
T35S
S.R.
SCL
2
1
6
PLANT SITE
12
11
10
9
8
13
S.R. 663
E. WHIDDEN RD
R24E | R25E
PROPERTY BOUNDARY
OUTPARCEL (NOT FARMLAND PROPERTY)
PRESERVED
RECLAMATION IN PROGRESS
RECLAMATION COMPLETE
ACTIVE MINING, WASTE DISPOSAL, OR ANCILLARY FACILITIES
N
0
2,000
4,000
SCALE IN FEET

FIGURE 2-35. EXTENT OF MINE RECLAMATION - YEAR 4.

SOURCE: FARMLAND INDUSTRIES, INC., HARDEE COUNTY MASTER PLAN, JUNE 1979

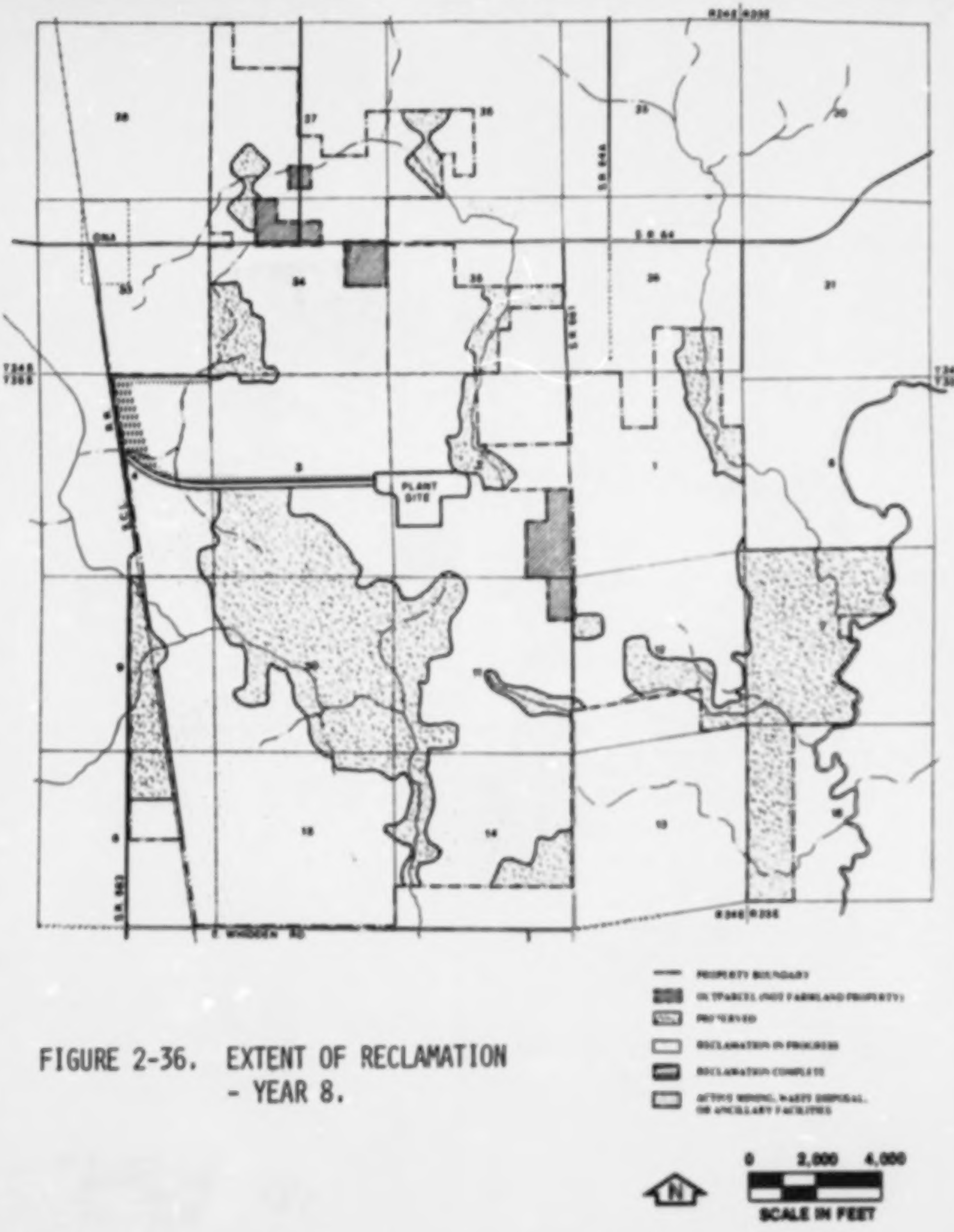
R24E R25E
S.R. 64
PLANT SITE
T34S
T35S
S.R. 663
WHIDDEN RD
PROPERTY BOUNDARY
OUTPARCEL (NOT FARMLAND PROPERTY)
PRESERVED
RECLAMATION IN PROGRESS
RECLAMATION COMPLETE
ACTIVE MINING, WASTE DISPOSAL, OR ANCILLARY FACILITIES
N
0 2,000 4,000
SCALE IN FEET

FIGURE 2-36. EXTENT OF RECLAMATION - YEAR 8.

SOURCE: FARMLAND INDUSTRIES, INC., HARDEE COUNTY MASTER PLAN, JUNE 1979

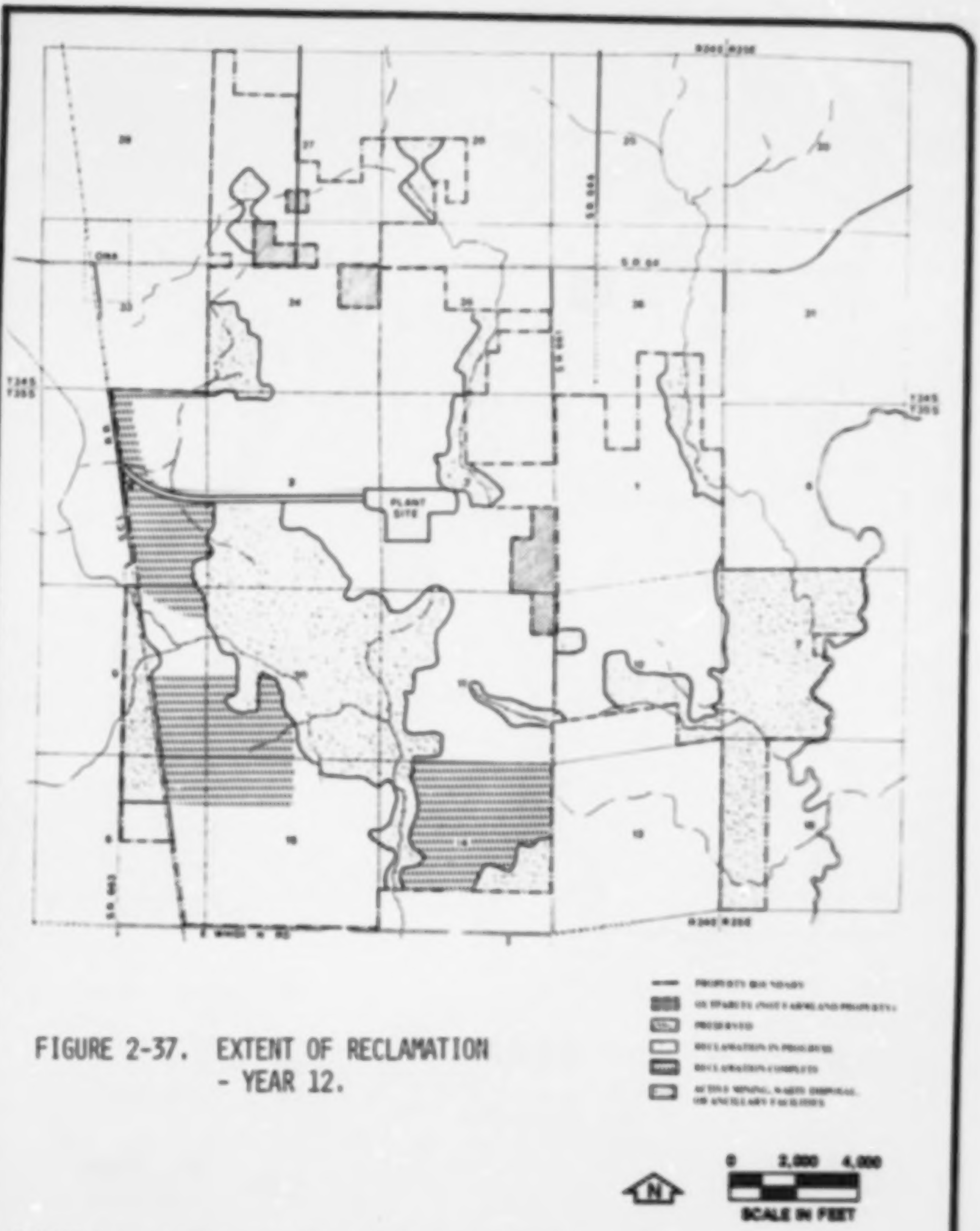
PLANT SITE
0 2,000 4,000
SCALE IN FEET
N

FIGURE 2-37. EXTENT OF RECLAMATION - YEAR 12.

SOURCE: FARMLAND INDUSTRIES, INC., HARDEE COUNTY MASTER PLAN, JUNE 1979

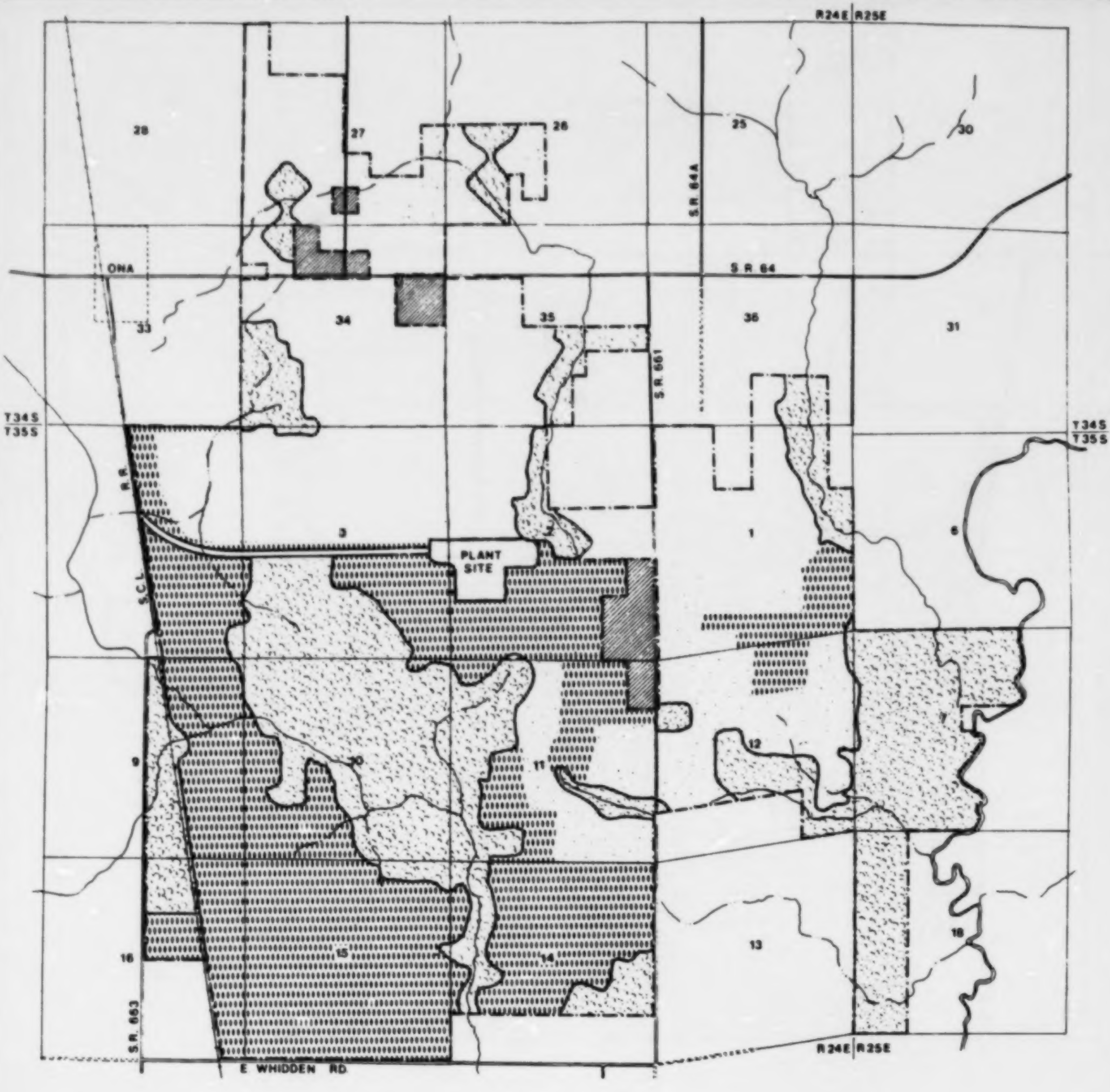
R24E R25E
28
27
26
25
30
S.R. 64A
ONA
S R 64
33
34
35
36
31
S.R. 661
T34S
T35S
R.R.
S.C.L.
3
1
6
PLANT SITE
9
10
11
12
7
16
15
14
13
18
S.R. 663
E WHIDDEN RD
R24E R25E
PROPERTY BOUNDARY
OUTPARCEL (NOT FARMLAND PROPERTY)
PRESERVED
RECLAMATION IN PROGRESS
RECLAMATION COMPLETE
ACTIVE MINING, WASTE DISPOSAL, OR ANCILLARY FACILITIES
N
0
2,000
4,000
SCALE IN FEET

FIGURE 2-38. EXTENT OF RECLAMATION - YEAR 16.

SOURCE: FARMLAND INDUSTRIES, INC., HARDEE COUNTY MASTER PLAN, JUNE 1979

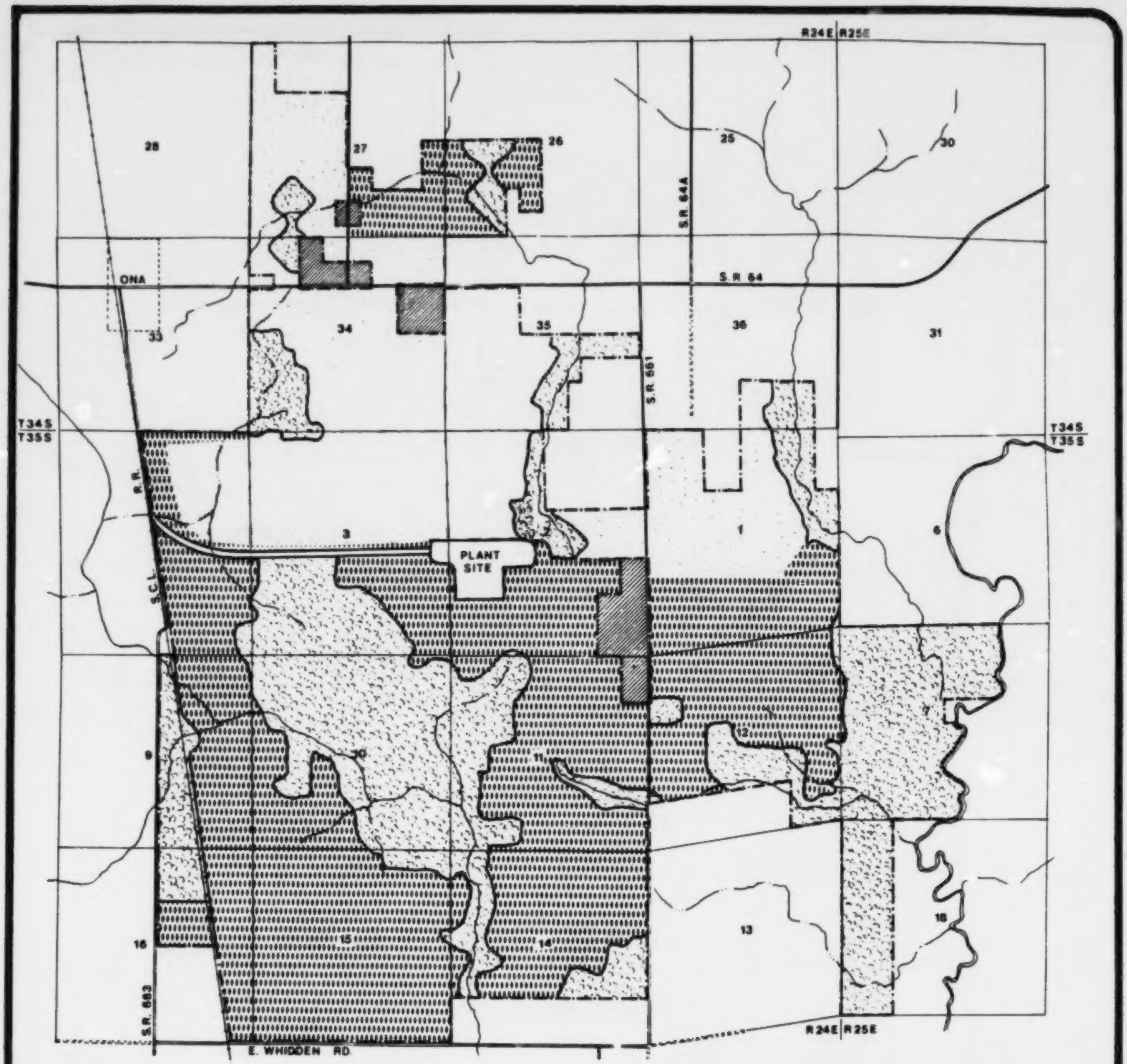
R24E | R25E
28
27
26
25
30
S.R. 64A
ONA
S.R. 64
33
34
35
36
31
S.R. 661
T34S
T35S
R.R.
S.C.L.
3
PLANT SITE
1
6
9
10
11
12
7
16
15
14
13
18
S.R. 663
E. WHIDDEN RD.
R24E | R25E
PROPERTY BOUNDARY
OUTPARCEL (NOT FARMLAND PROPERTY)
PRESERVED
RECLAMATION IN PROGRESS
RECLAMATION COMPLETE
ACTIVE MINING, WASTE DISPOSAL, OR ANCILLARY FACILITIES
N
0 2,000 4,000
SCALE IN FEET

FIGURE 2-39. EXTENT OF RECLAMATION
- YEAR 20.

SOURCE: FARMLAND INDUSTRIES, INC., HARDEE COUNTY MASTER PLAN, JUNE 1979

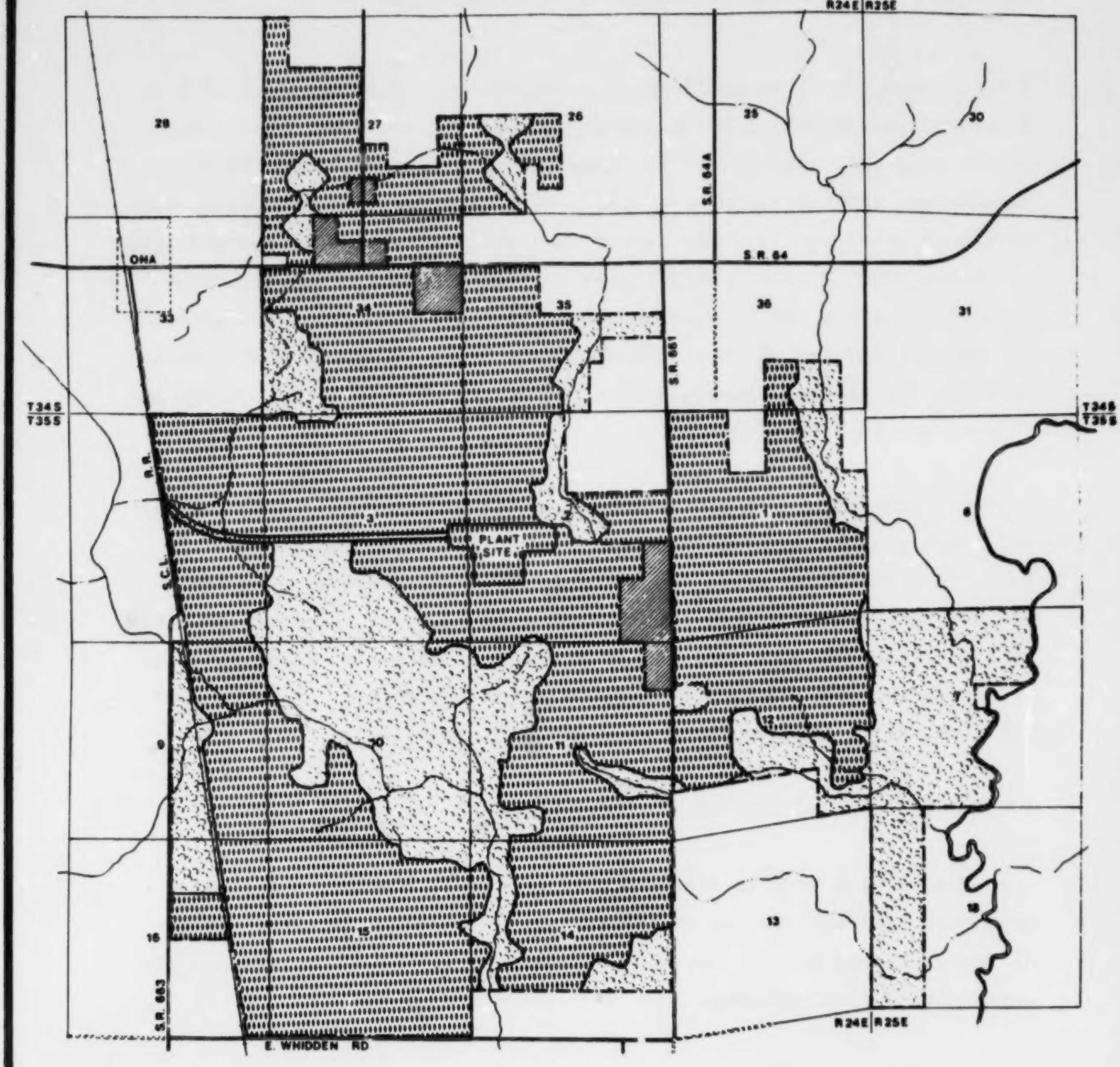
R24E R25E
28
27
26
25
30
S.R. 64A
ONA
S.R. 64
33
34
35
36
31
S.R. 661
T34S
T35S
T34S
T35S
R.R.
S.C.L.
3
PLANT SITE
1
6
9
10
11
12
7
16
15
14
13
18
S.R. 663
E. WHIDDEN RD
R24E R25E
PROPERTY BOUNDARY
OUTPARCEL (NOT FARMLAND PROPERTY)
PRESERVED
RECLAMATION IN PROGRESS
RECLAMATION COMPLETE
N
0
2,000
4,000
SCALE IN FEET

FIGURE 2-40. EXTENT OF RECLAMATION - COMPLETE.

SOURCE: FARMLAND INDUSTRIES, INC., HARDEE COUNTY MASTER PLAN, JUNE 1979

2 more years for final grading and revegetation. Thus, a total of 5 to 6 years is estimated to be required for complete reclamation of individual sand-clay landfills. By comparison, 10 years has been allotted to complete reclamation of the single clay settling area remaining after mining is complete. Reclamation of sand tailings fill and land and lake areas can proceed more rapidly since the subsidence and consolidation period for such areas is much shorter. Two to 3 years has been allotted for the reclamation of these areas, depending on the particular area in question. A proposed schedule of acreages reclaimed for the mining area is included in Table 2-10.

Reclamation of all disturbed areas will begin shortly after mining and waste disposal activities cease in the individual blocks. Therefore, once the initial lag period is over, reclamation will proceed rapidly and keep pace with the disturbance throughout the remaining life of the mine. When the reclamation of the last sand-clay landfill area is completed, approximately 4 years after mining ceases, 89 percent of the disturbed land is scheduled to have been reclaimed.

2.6.4 PHYSICAL RECLAMATION OF DISTURBED AREAS

The initial step in the reclamation of all mined or otherwise disturbed land will be the restructuring, drainage, and/or backfilling of the disturbed sites. Physical restoration is closely related to the waste disposal methodology.

The following five general types of physical restoration will be employed in Farmland's reclamation program:

- sand-clay mix landfill
- crust development on clay settling areas
- sand tailings landfill
- land and lakes construction
- restoration of disturbed natural ground

Figure 2-41 shows the location of the various restoration areas on the mine site. The methods employed and the land forms resulting from each of these types of restoration are discussed in the following sections. For planning purposes, exact acreage figures have been assigned to the various areas. In actual practice, the acreages may vary somewhat from the figures presented in this conceptual plan.

Sand-Clay Mix

Use of a sand and clay mixture in backfilling mine cuts was selected as the predominant physical restoration technique to be used because of its significant advantages. Since sand-clay mixtures can be expected to stabilize more rapidly than the clays alone, reclamation is expected to proceed at a more rapid rate than is possible for conventional clay settling areas. In addition, properly mixed sand-clay soils are expected to be agriculturally superior to either the sand or clay alone.

Sand-clay landfills are expected to undergo an initial period of rapid dewatering and subsidence followed by a prolonged period of gradual consolidation and further subsidence. In order to allow for this subsidence, it is essential that sand-clay landfills be filled initially to above natural grade. Except in two areas designed for wetland restoration (special Sand-Clay Mix Areas 1 and 2), the level of filling will be adjusted so that the landfills will ultimately subside to slightly above original grade. Twenty-five sand-clay landfills of this type will cover an area of approximately 3628 acres. Table 2-11 lists a schedule of these 25 landfills plus two special mix areas. Figure 2-41 illustrates the location of these landfills.

Figure 2-42 provides a cross sectional view of a typical sand-clay landfill. Subsidence of the sand-clay fill between protruding spoil piles will result in a slightly undulating topography. Because of the expected agricultural superiority of the sand-clay soils, no attempt to

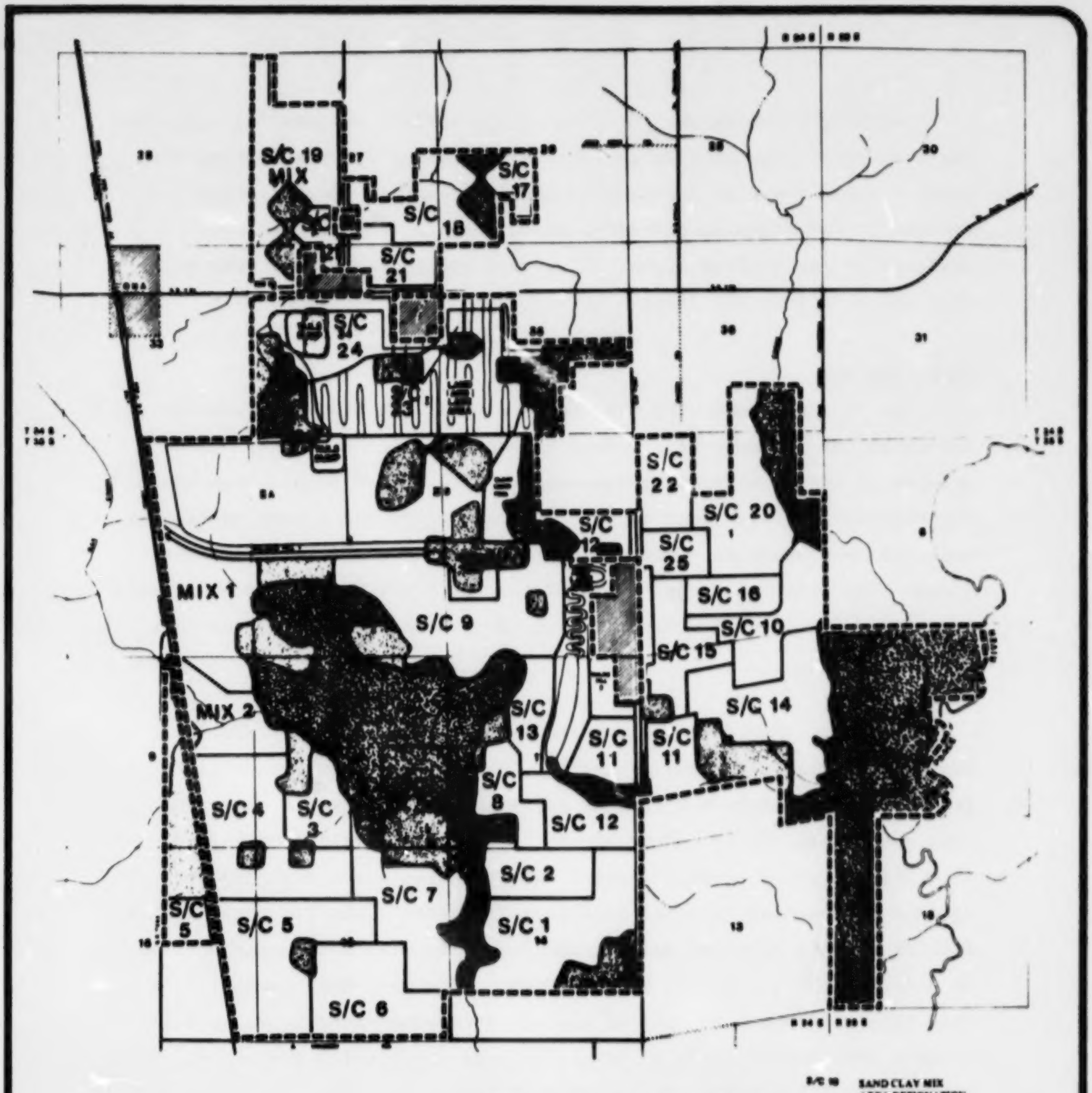
S/C 19 MIX
S/C 17
S/C 18
S/C 21
S/C 24
S/C 23
S/C 22
S/C 20
S/C 12
S/C 25
S/C 16
S/C 10
S/C 9
S/C 15
MIX 1
MIX 2
S/C 14
S/C 13
S/C 11
S/C 11
S/C 8
S/C 4
S/C 3
S/C 12
S/C 2
S/C 7
S/C 5
S/C 5
S/C 1
S/C 6
OUT PARCEL (NOT FARMLAND PROPERTY)
UNMINEABLE AREA ENVIRONMENTAL SENSITIVITY
UNMINEABLE AREA MINE PLANNING
S/C 10 SAND CLAY MIX AREA DESIGNATION
MIX 1 SPECIAL SAND CLAY MIX AREA Dredged Clay Fill Allowing For Final Settling Near Original Elevation.
S/C 19 MIX SPECIAL SAND CLAY MIX AREA Dredged Clay Fill Allowing For Final Settling To Be Approximately 4 Feet Above Original Elevation.
N
0 2,000 4,000
SCALE IN FEET

FIGURE 2-41. SAND-CLAY WASTE DISPOSAL AREAS.

SOURCE: FARMLAND INDUSTRIES, INC., HARDEE COUNTY MASTER PLAN, JUNE 1979

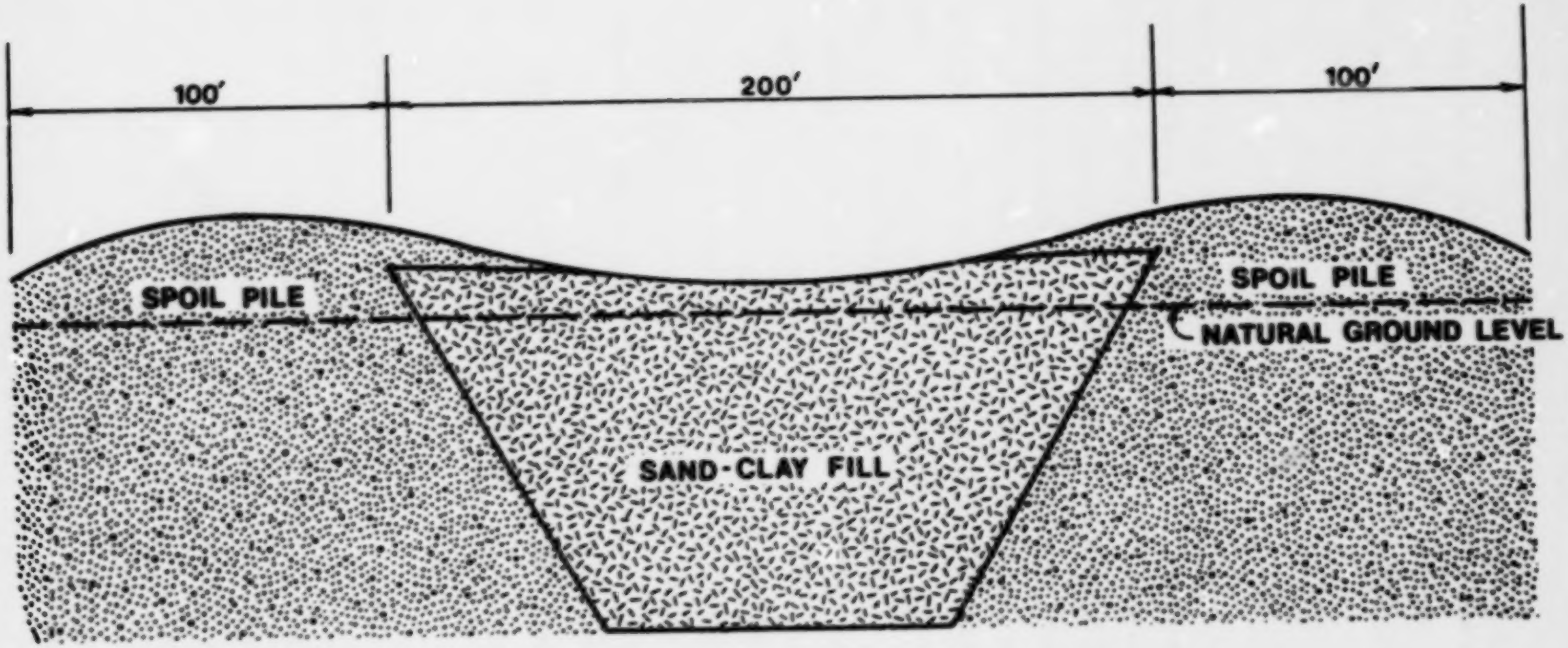
100'
200'
100'
SPOIL PILE
SPOIL PILE
NATURAL GROUND LEVEL
SAND-CLAY FILL

FIGURE 2-42. CROSS-SECTIONAL VIEW OF SAND-CLAY LANDFILL SHOWING SURFACE SOIL CHARACTER AND SUBSIDENCE OF FILL BETWEEN SPOIL PILES.

SOURCE: FARMLAND INDUSTRIES, INC., HARDEE COUNTY MASTER PLAN, JUNE 1979

cap sand-clay landfills with overburden will be made beyond the grading of overburden spoils to approved slopes. Sand-clay landfills, therefore, can be expected to be roughly equally divided between overburden and sand-clay soils.

Clay Settling Area

When mining is complete, only one conventional clay settling area will remain (Settling Area II, covering 583 acres). The crust development technique will be used to reclaim this settling area. When the area is deactivated, surface water will be drawn off through the in-place spillways and a perimeter ditch will be dug to establish initial drainage. As conditions permit, internal drainage ditches will be installed with specialized equipment, such as ditching plows pulled by low-ground pressure vehicles, to promote further surface drying. Within 4 to 5 years, the drying clays should subside considerably in the settling area. When a crust of sufficient stability to support machinery has formed, volunteer vegetation will be cleared from the area. The retaining dam and any protruding spoil piles will be pushed down to conform to slope requirements and to fill any depressions persisting within the area. There are no further plans to cover the clays with overburden since the clays are very fertile and when properly managed, can be very productive agricultural soils. All spillways will be removed and final drainage established through inter-spoil swales. The area will then be revegetated to complete reclamation.

Sand Tailings Fill

As shown in Figure 2-41, sand tailings will be deposited over two small areas covering a total of 104 acres. These will eventually be covered with overburden and graded to a depth of approximately 2 feet to provide for the establishment of a good vegetative cover. Two years has been allotted to complete reclamation by grading of spoils and revegetation.

Lake Areas

The reclamation plan includes the creation of lakes in three areas shown in Figure 2-43. These consist of the clear water pool at the beneficiation plant, the drainage system left for Hickory Creek, and the depressions left as a result of the last 2 years of mining. These are described in more detail in the following paragraphs.

Clear Water Pool. The pit created during the first year of operation will serve as the plant clear water pool throughout the remaining life of the mine. In mining this area, spoiling patterns will be utilized that maximize the amount of volume available for below-grade water storage. Initial water depths in the lake will average around 30 feet; but over the 20-year life of the mine, sedimentation from turbid water in the plant water system will reduce the average depth somewhat. When mining is complete, the water level in the lake will be drawn down and spoils from the margins of the lake graded into the void to conform to slope requirements. This will form a littoral zone around the lake and result in an average depth not exceeding 15 feet.

Hickory Creek. Mining in the present Hickory Creek channel in years 13 and 14 will be done so as to create a lake system through which Hickory Creek will be rerouted. As shown in Figure 2-44, the upper portion of this 140-acre area will consist of a series of finger lakes which form a meandering channel for the creek. The lower portion of the lake system will consist of an open lake about 600 feet wide and 3000 feet long created by double spoiling the parallel mine cuts adjacent to this area. The lake system will intercept the undisturbed portion of the Hickory Creek channel at an elevation of approximately 65 feet and serve as the area's outfall into the natural floodplain at this point, thus establishing the water level in the entire lake system. Figure 2-45 provides a cross-sectional view of the water and land surfaces for the lake system.

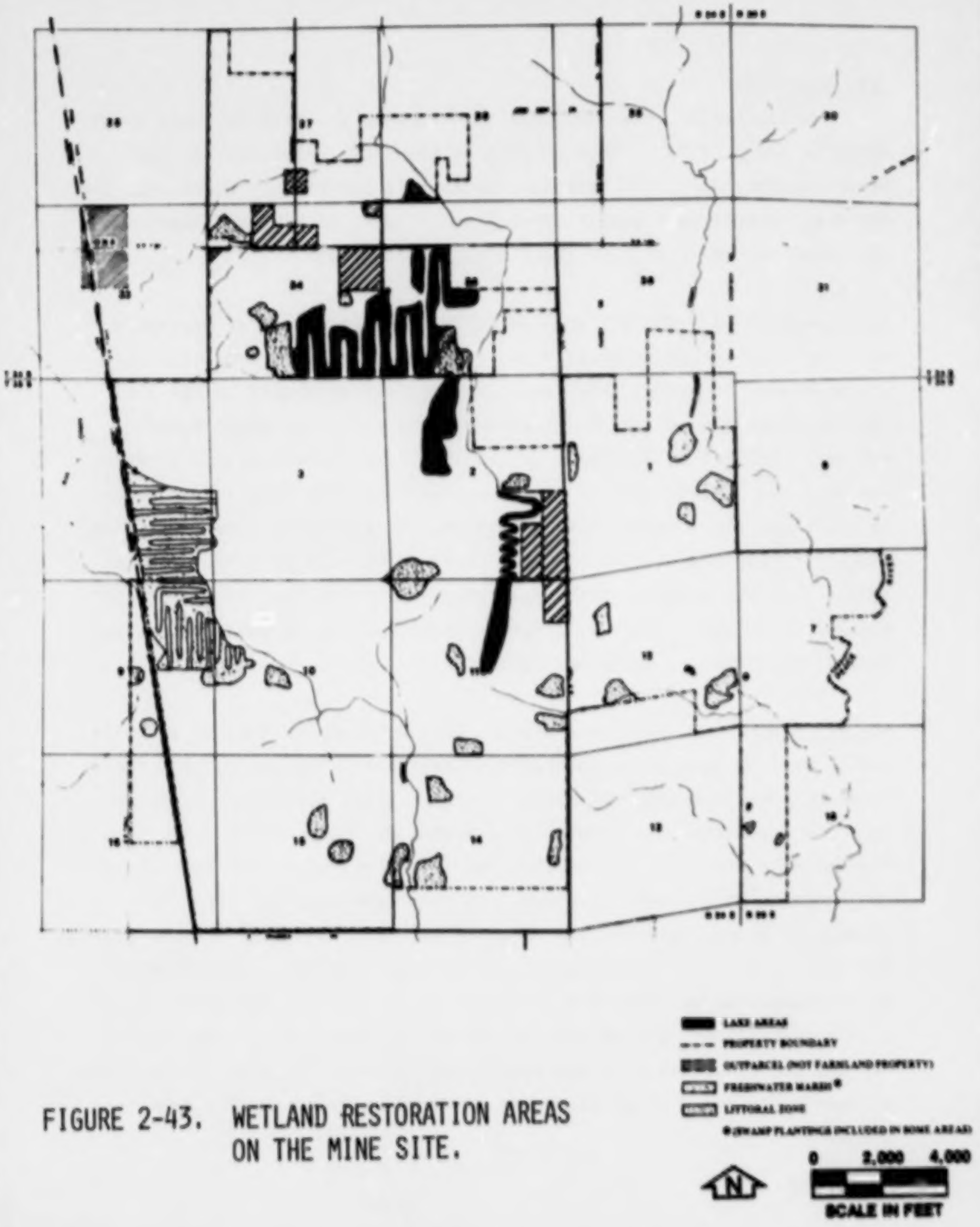
LAKE AREAS
PROPERTY BOUNDARY
OUTPARCEL (NOT FARMLAND PROPERTY)
FRESHWATER MARSH*
LITTORAL ZONE
*(SWAMP PLANTINGS INCLUDED IN SOME AREAS)
N
0 2,000 4,000
SCALE IN FEET

FIGURE 2-43. WETLAND RESTORATION AREAS ON THE MINE SITE.

SOURCE: FARMLAND INDUSTRIES, INC., HARDEE COUNTY MASTER PLAN, JUNE 1979

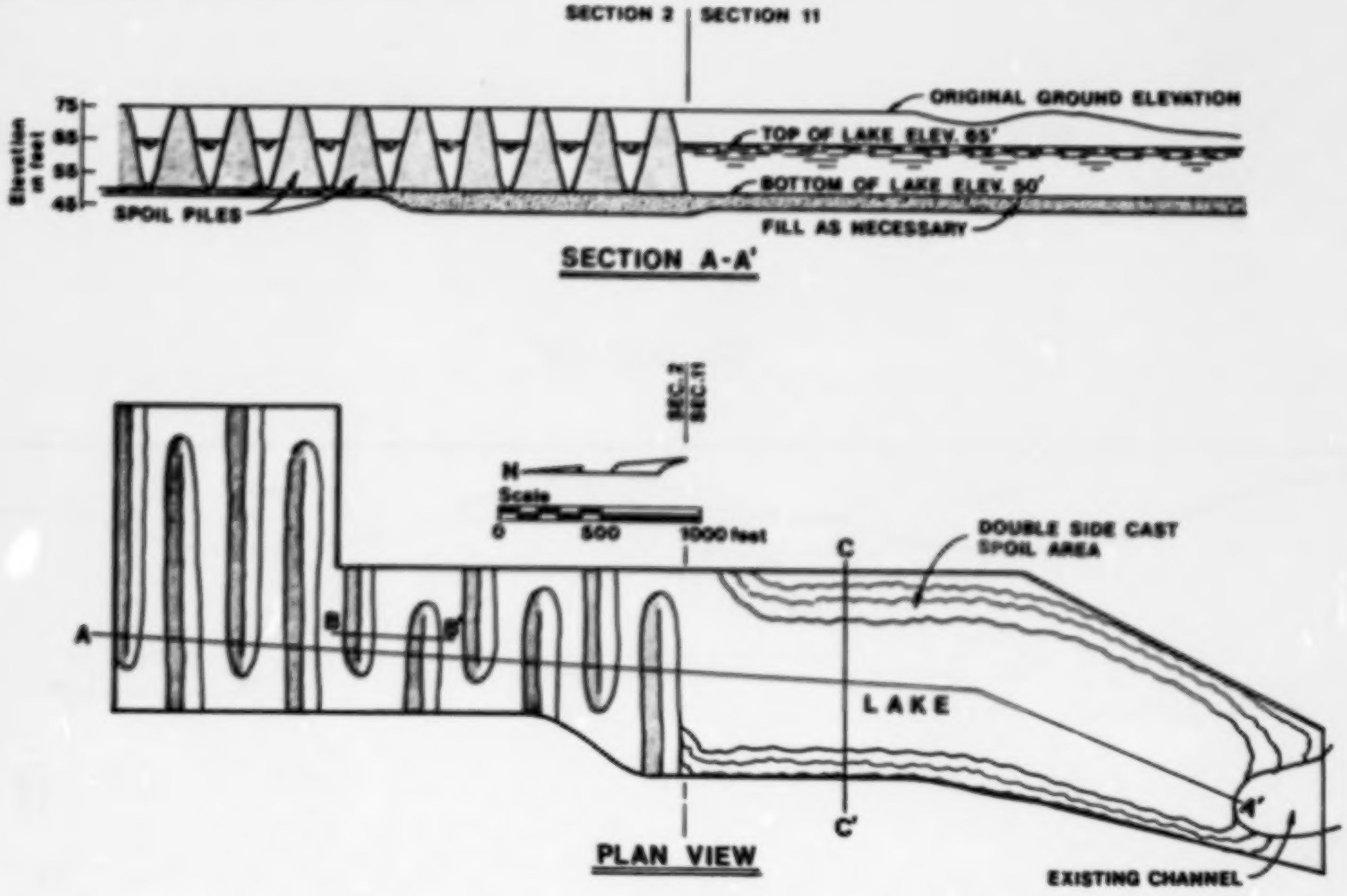
SECTION 2
SECTION 11
Elevation in feet
75
65
55
45
ORIGINAL GROUND ELEVATION
TOP OF LAKE ELEV. 65'
BOTTOM OF LAKE ELEV. 50'
SPOIL PILES
FILL AS NECESSARY
SECTION A-A'
SEC.2
SEC.11
N
Scale
0
500
1000 feet
A
B
B'
C
C'
A'
DOUBLE SIDE CAST SPOIL AREA
LAKE
EXISTING CHANNEL
PLAN VIEW

FIGURE 2-44. PHYSICAL CHARACTERISTICS OF THE LAKE SYSTEM TO BE CREATED BY RECLAMATION IN SECTIONS 2 AND 11, T35S, R24E.

SOURCE: FARMLAND INDUSTRIES, INC., DRI, JUNE 1979

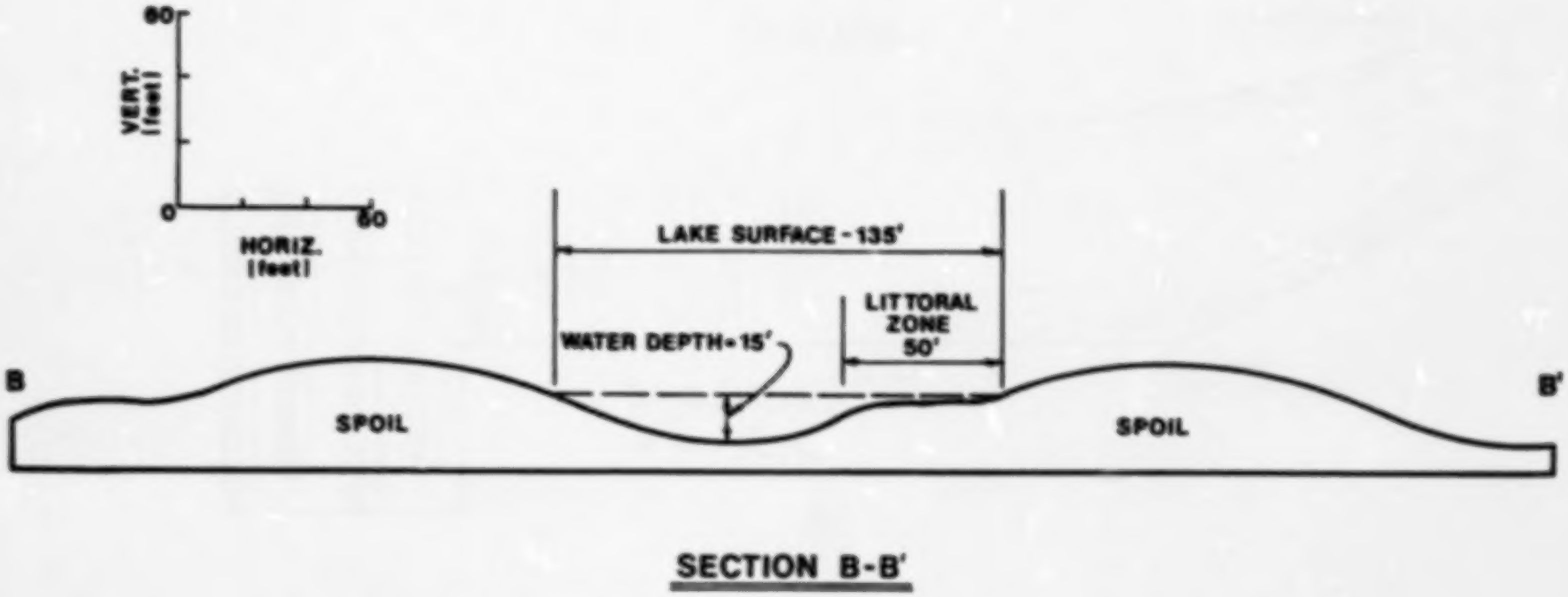
60
VERT.
(feet)
0
60
HORIZ.
(feet)
LAKE SURFACE - 135'
LITTORAL
ZONE
50'
WATER DEPTH - 15'
B
B'
SPOIL
SPOIL
SECTION B-B'

FIGURE 2-45. PHYSICAL DESIGN CONCEPTS FOR FINGER LAKE RECLAMATION AREA IN SECTION 2, T35S, R24E.

SOURCE: FARMLAND INDUSTRIES, INC., DRI, JUNE 1979

During reclamation of these lake areas, overburden from the spoils in the finger lake portion of the area will be graded into the mine cuts to (1) conform to slope requirements, (2) fill in the cuts to establish a maximum water depth of 15 feet, and (3) form a 50-foot wide littoral zone on one side of the lake as shown in Figure 2-45. In the open water lake in the lower portion of the area, the double spoil piles on the east side will be graded into the mine cut to form a 100-foot wide littoral zone approximately 1-3 feet deep as shown in Figure 2-46. On the west side of the mine cut, only a single spoil pile will be available to provide overburden fill for the mine cut. Tailings sand will, therefore, be used to supplement the fill on this side of the mine cut in order to establish a 12 to 1 slope out to a depth of 15 feet. When reclamation is complete, the area will be approximately equally divided between water and land surface.

Since the mining of this area includes the channel and floodplain of Hickory Creek, mining and reclamation will be completed as rapidly as possible. Mining of the area is planned to take place over a period of slightly over 2 years, beginning in year 12 and ending early in year 14. Physical and revegetative restoration of the area will require a period of 2 years before the creek is rerouted through the system. The period of actual downstream flow disruption will, therefore, have been kept to slightly over 4 years.

Land and Lakes Area. The land and lakes area to be created during the last 2 years of mining will be a 368-acre area previously occupied by Settling Area I. Double spoiling patterns will be utilized in the mining of this area in order to create a land and lakes area. Topography in the area is such that inflow to the lakes will be from the northwest, with lake outfalls potentially located in both the southwest and southeast corners--so that they could discharge to a tributary of Oak Creek or to Hickory Creek, respectively. As shown in Figure 2-47,

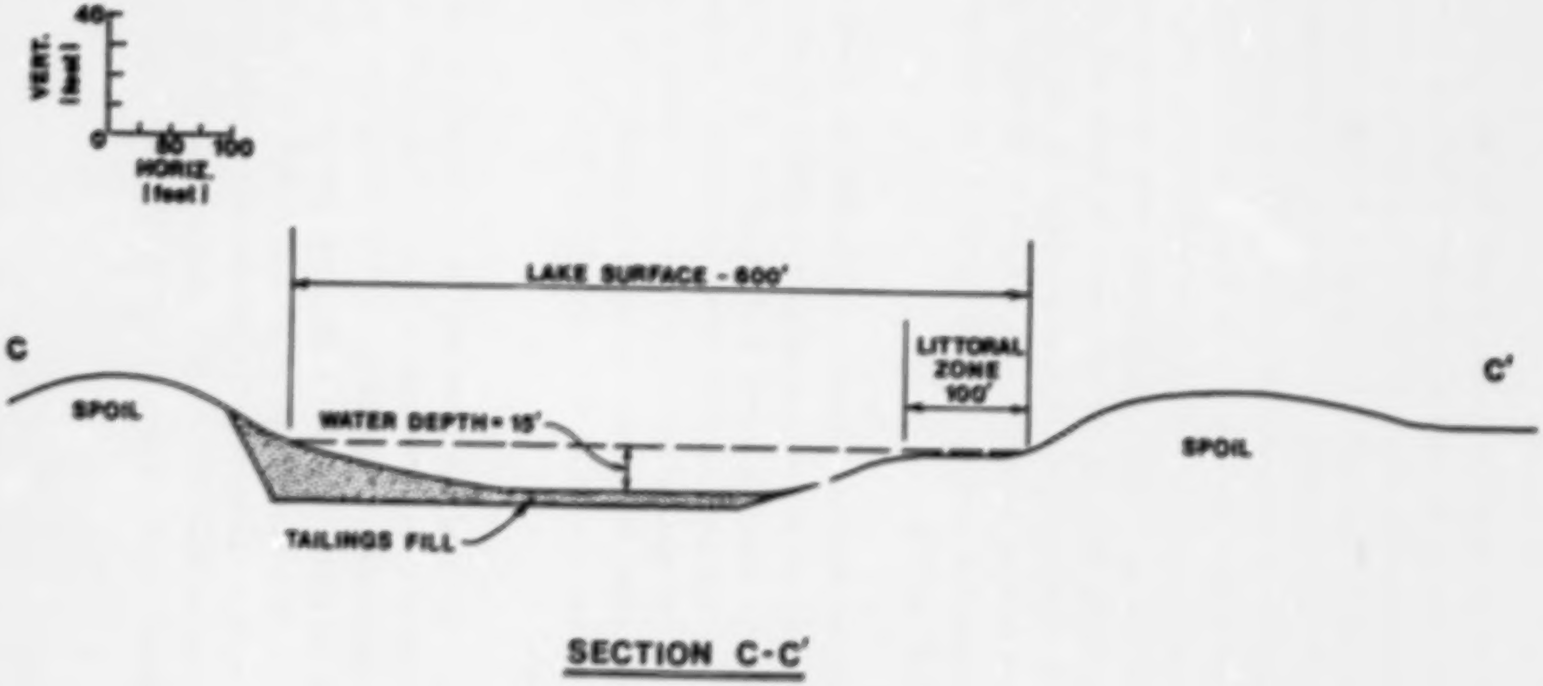
VERT. (feet)
40
0
50
100
HORIZ. (feet)
LAKE SURFACE - 600'
C
C'
LITTORAL ZONE 100'
SPOIL
WATER DEPTH = 15'
SPOIL
TAILINGS FILL
SECTION C-C'

FIGURE 2-46. PHYSICAL DESIGN CONCEPTS FOR THE OPEN LAKE RECLAMATION AREA IN SECTION 11, T35S, R24E.

SOURCE: FARMLAND INDUSTRIES, INC., DRI, JUNE 1979

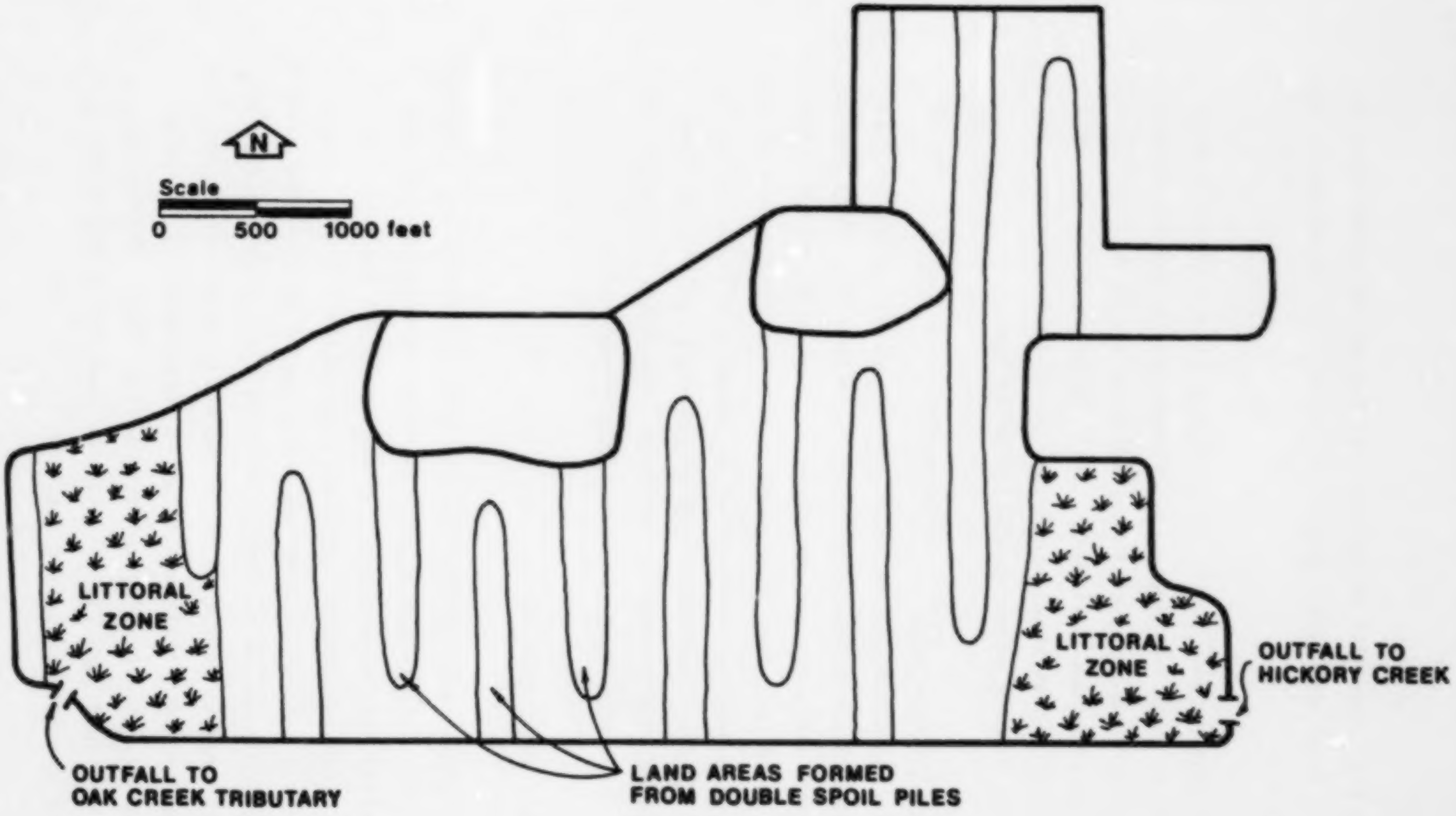
N
Scale
0
500
1000 feet
LITTORAL ZONE
LITTORAL ZONE
OUTFALL TO HICKORY CREEK
OUTFALL TO OAK CREEK TRIBUTARY
LAND AREAS FORMED FROM DOUBLE SPOIL PILES

FIGURE 2-47. PHYSICAL CHARACTERISTICS OF THE LARGE LAND AND LAKE AREA IN SECTIONS 34 AND 35, T34S, R24E.

SOURCE: FARMLAND INDUSTRIES, INC., DRI, JUNE 1979

extensive littoral zones will be created by grading the overburden in the vicinity of these outfalls. Weirs will establish and maintain the lake outfall levels.

All other spoil piles in this area will be graded into the mine cuts to conform to slope requirements. Mining depths and the groundwater table in the area are such that grading of spoils will achieve a maximum water depth of about 15 feet. Reclamation in this area will result in the creation of about equal amounts of land and water, and be completed within 3 years after completion of mining.

Disturbed Natural Ground Area

When mining is complete, the beneficiation plant, entrance railroad, and other ancillary facilities will be dismantled. Only facilities such as storage sheds and the plant entrance road will be retained if it is determined that they will benefit post-reclamation use of the site. Salvageable material will either be moved to new mine sites or sold to scrap dealers. Materials such as concrete foundations that cannot be salvaged will be used as landfill. The disturbed sites will be graded, if necessary, to conform to slope requirements.

2.6.5 REVEGETATION METHODOLOGY

The reclamation plan provides for the revegetation of all disturbed land. Figure 2-32 depicts the vegetative cover planned for the mine site after reclamation is complete. In designing the revegetation program, the following specific goals were established: (1) rapid establishment of a vegetative cover on reclaimed soils in order to meet regulatory requirements and to prevent erosion and turbid runoff; (2) accumulation of organic matter in reclaimed soils to enhance their productivity and broaden their agricultural potential; (3) adequate revegetation of environmental restoration areas; (4) aesthetic enhancement of reclaimed land; and (5) selection of species to match potential productivity of the various soil types.

Experimental Sand-Clay Mix Revegetation Area

The land use potential of sand-clay soils is a major component of the overall reclamation plan. In the absence of actual field experience with such soils, it is difficult to predict their best use for agriculture. The physical restoration plan also calls for the creation of approximately 325 acres of wetland environments in sand-clay landfills. The measures appropriate to revegetating these areas are presently undetermined; however, research is ongoing to develop wetland revegetation technology.

Farmland plans to implement an experimental revegetation program on the first sand-clay landfill that becomes available during reclamation, and to evaluate the results of this program and of other similar experimental programs. Sand-clay Area I, encompassing 236 total acres, will have been filled by the end of year 5 and undergone its initial rapid subsidence phase by the end of year 7. Of the total 236 acres, approximately 12 acres will consist of the hydric environment created near the outlet end, while the remainder will be approximately equally divided between upslope sand-clay and overburden soils. An experimental revegetation program aimed at determining the agricultural land use potential of these areas will be initiated in the upslope portions, while a wetland revegetation program will be initiated in the hydric portion.

Strip plantings of forage crops, commercial forest species, truck crops, field crops, and citrus will be included in the upland experimental area. Planting strips will be made at right angles to the old mining cuts and spoil piles (see Figure 2-48) so that each planting will be partly on overburden and partly on sand-clay soils. University of Florida Extension specialists will be consulted in planning the experimental plantings. A degree of flexibility will be retained in relation to the exact plantings and programs since new varieties and cultural practices that have application for these soils may be suggested as a result of continued experimental work. The basic intent of the upland

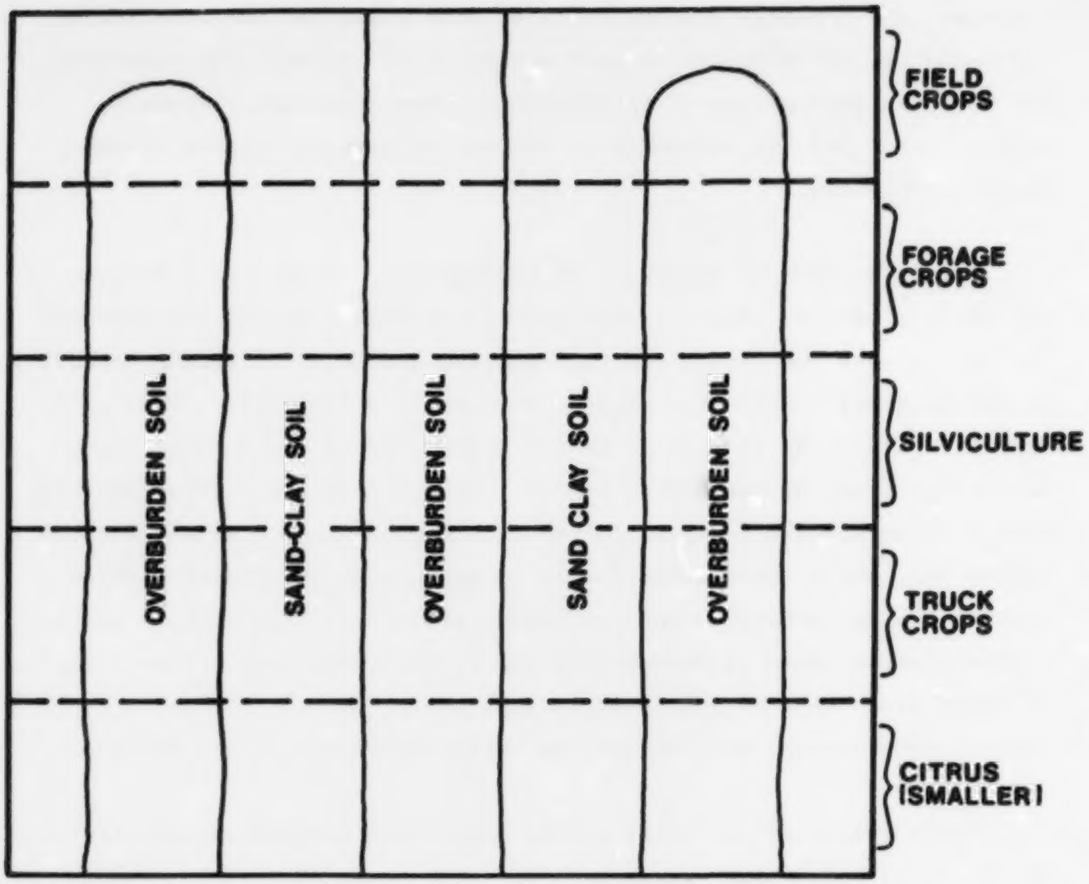
OVERBURDEN SOIL
SAND-CLAY SOIL
OVERBURDEN SOIL
SAND CLAY SOIL
OVERBURDEN SOIL
FIELD CROPS
FORAGE CROPS
SILVICULTURE
TRUCK CROPS
CITRUS (SMALLER)

FIGURE 2-48. EXPERIMENTAL VEGETATION PLANTINGS IN SAND-CLAY MIX AREA 1.

SOURCE: FARMLAND INDUSTRIES, INC., DRI, JUNE 1979

experimental plantings will be to determine the highest and best agricultural use of sand-clay landfill soils.

The truck crop portion of the experimental plantings will be emphasized. Truck crops favor moist, fertile soils with properties similar to sand-clay soils. Hardee County is a traditional truck farming area, and truck crops may prove to be the high value crops best suited to replace the citrus acreage lost to mining. Traditional Hardee County crops such as cucumbers and squash will be included among those tested. Tomatoes, which favor soils high in calcium, also warrant inclusion in the experimental program.

Field crops are not commonly grown in central Florida, partially because of unfavorable soil conditions which sand-clay soils may eliminate. Plantings of field corn and soybean varieties will, therefore, be included in the field crop plantings. Soybean varieties adapted to double-cropping behind truck crops will be emphasized. Other upland plantings may also enhance the economic productivity of the reclaimed site. In the forage crop plantings, grass and legume varieties that have the potential for taking advantage of the high fertility of these soils will be compared with the accepted varieties such as bahiagrass. Eucalyptus and slash pine will also be included in the commercial forest plantings.

A small planting of citrus is also proposed for the experimental area. Citrus has been shown to thrive on some overburden sites in existing mining areas. Citrus does not thrive in soils that are wet for a significant part of the year, and it is quite possible that citrus will do poorly on sand-clay soils. The more upland sand-clay soils may, however, prove to be suitable. The experimental plantings are intended to resolve such questions.

Wetland revegetation research is also planned for a portion of the experimental area to help resolve remaining questions concerning the best methods of encouraging the development of wetland vegetation in man-made hydric environments. Research on this topic is currently being emphasized, not only in the Florida phosphate industry, but in other areas as well. Based on the current state-of-the-art in wetland reclamation the initial wetland area might include the following experimental plots: (1) areas in which volunteer vegetation is allowed to develop; (2) areas in which organic substrates removed from disturbed marshes onsite are introduced to provide a source for the introduction of natural marsh vegetation; (3) areas in which plantings of typical marsh-type species such as maidencane, pickerelweed, and arrowhead are made; and (4) areas in which plantings of hydric tree species--such as bald cypress, blackgum, sweetgum, and red maple are made (trees of 2-4 inch diameter transplanted from onsite disturbed areas would be included along with bareroot and potted seedlings to help determine the optimum transplant size for forested wetland restoration). The knowledge gained in both the upland and wetland experimental plantings will be used to guide revegetation plans for the remaining life of the mine. For the present, the revegetation plans developed for the entire tract are based on technology that is currently available or projected to be available in the near future. Concepts will be modified to take advantage of future technological improvements which may be forthcoming.

Improved Pasture

With the exception of the Experimental Sand-Clay Area, all upland disturbed land will initially be planted in forage species. This will serve a two-fold purpose: (1) the stabilization of reclaimed soils against erosion, and (2) the accumulation of organic matter in the disturbed soils. Both of these functions are stated goals of the revegetation effort. On the majority of reclaimed land, present plans provide for forage plantings to be maintained initially as improved pastures. Table 2-12 lists the improved pasture acreage that will be created in the various physical restoration areas.

Forage species to be planted on the various reclaimed areas will be carefully selected to match soil productivity. Unless the experimental plantings show more promising varieties, Coastal Bermudagrass and Pensacola Bahiagrass will be permanent grasses used in the forage revegetation. Coastal Bermudagrass will be planted on overburden and well-drained sand-clay soils. This grass produces high yields of excellent quality forage on fertile, well-drained soils, but does not do well on wet soils. Therefore, Pensacola Bahiagrass will be planted in the clay settling area and the more poorly drained sand-clay soils. Although not so productive as Coastal, this grass can withstand periodic inundation and has been found productive on reclaimed clay settling areas. Bahiagrass, which is also well-suited to the fertility and drainage characteristics of the native soils, will be used as the permanent grass for revegetating disturbed native soils.

It is not intended that all upland areas remain as improved pasture areas for the long-term as this would clearly not satisfy environmental, aesthetic, and economic goals for the site. The initial forage plantings will make it possible to subsequently plant trees in stabilized soils. The forage species will offer some early competition to seedling trees, but the majority can be expected to overcome this competition. Should a conversion to row crops be desired, forage sods can be destroyed by heavy discing or herbicide application prior to the planting. After a period of intensive cultivation, the row-cropped areas can also be returned to pasture. Similar pasture/vegetable rotations are commonly practiced by Florida farmers on natural ground.

Legumes will also be included in all forage plantings. In general, legumes favor soils with pH levels near neutral and high levels of available calcium, magnesium, and phosphorus. White clover, an important cool season legume which trives on the moist, fertile soils of reclaimed settling areas, will be used as the legume component in the forage plantings on the clay settling area. It is also likely that white clover would do well on sand-clay soils; however, since sand-clay landfills will be divided between overburden and sand-clay soils, a more practical selection for these areas is aeschynomene (which will thrive on both soil types). In fact, this native legume frequently volunteers on mined land. It is utilized not only by cattle but also by wildlife (e.g., white-tailed deer). Hairy indigo will be the legume used on natural soil plantings, as it is well adapted to the moderate to low fertility of these soils.

In the initial plantings of all forages, a seedbed will be prepared by tilling the land with a heavy disc. Fertilizer and lime requirements will be determined by soil tests, and appropriate applications made. In areas to be planted in Bermudagrass, fresh vegetative sprigs will be broadcast over the area followed by a light discing and rolling with a cultipacker to incorporate the sprigs and firm the seedbed. Areas to be planted in Bahiagrass will be broadcast seeded and lightly disced to incorporate the seed.

In areas particularly sensitive to erosion, such as sloping areas near stream courses, rapidly germinating temporary forages such as millet or rye will be interplanted with the permanent grasses. These temporary forages will form an initial ground cover more rapidly than the permanent grasses. As they mature and die, the slower-to-establish permanent grasses will gradually take over. In areas where erosion is not expected to be a problem, the temporary forages will not be used since they compete with the permanent grasses to some extent and may actually slow the establishment of a permanent grass sod.

When the grass sods have become firmly established, the grass will be grazed or mowed closely and the sod opened with a light discing. The appropriate legume will then be broadcast seeded over the open sod and rolled in with a cultipacker. These legume plantings will supply nitrogen to the pasture plantings and will in many cases eliminate the need for further fertilization, particularly on clay and sand-clay soils. The need for supplemental fertilization will be determined by soil tests, and nutrients will be applied as needed to maintain a productive pasture.

Reforestation

Reforestation plantings provided for in the reclamation plan are intended primarily to fulfill environmental and aesthetic goals for the reclaimed site. The potential of commercial forest plantings of both slash pine and eucalyptus will be evaluated in the experimental revegetation area. If these plantings prove to be promising, commercial forest plantings may be expanded in the following stages of the reclamation effort. However, based on current knowledge no commercial forest plantings are planned. Forest plantings are not as effective as forages in preventing erosion or encouraging organic matter accumulation in reclaimed soils. In addition, forest plantings would make it more difficult to initiate more intensive agricultural land uses at a later date.

Three types of reforestation plantings are planned in the revegetation program. These are discussed below; Table 2-13 lists the acreage each will involve.

Sand-Clay Mix Plantings. In the two special sand-clay mix areas where the sand-clay filled mining cuts will form the broad hydric floodplains for the rerouting of Oak Creek and one of its tributaries, the graded spoils occupying the more upland portions will be planted in mixed forest. Figure 2-49 depicts the proposed planting program for these areas. Only native species will be used in the plantings. Mesic species such as slash pine, laurel oak, and water oak will be used in the more upland areas, whereas hydric species such as blackgum, sweetgum, red maple, and bald cypress will be used near the water's edge.

Strip Plantings. In all other sand-clay landfills and in the reclaimed clay settling area, strip plantings of a mixture of forest species will

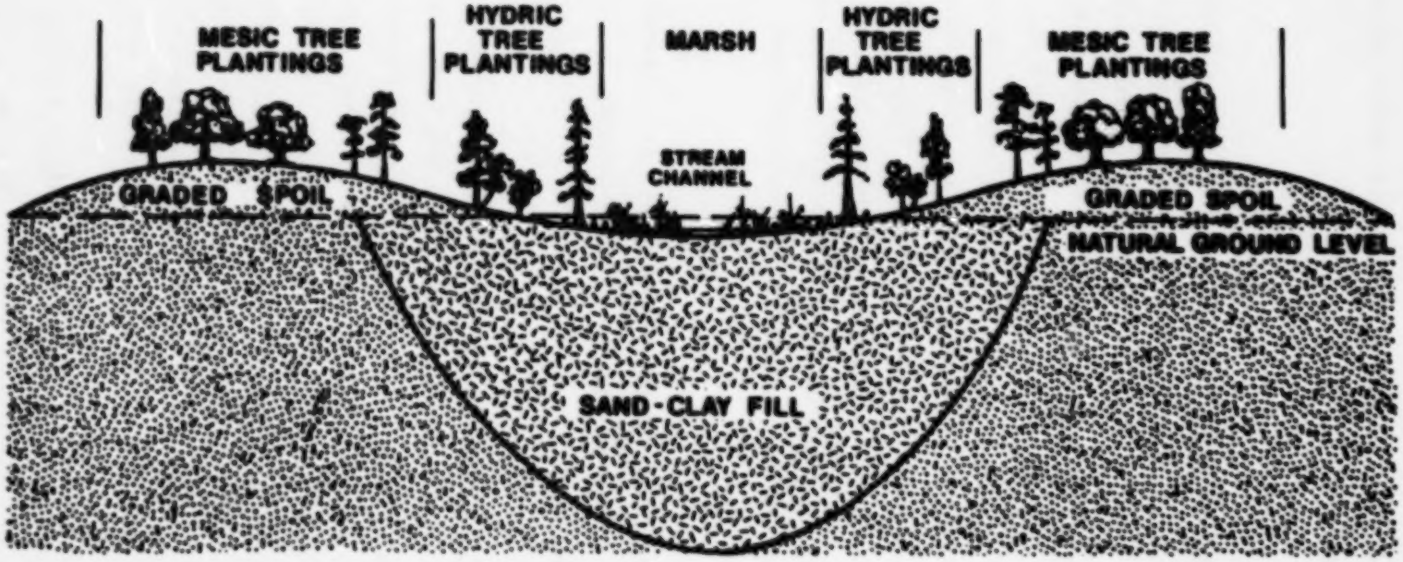
MESIC TREE PLANTINGS
HYDRIC TREE PLANTINGS
MARSH
HYDRIC TREE PLANTINGS
MESIC TREE PLANTINGS
STREAM CHANNEL
GRADED SPOIL
GRADED SPOIL
NATURAL GROUND LEVEL
SAND-CLAY FILL

FIGURE 2-49. REFORESTATION OF SPECIAL SAND-CLAY MIX AREAS 1 AND 2.

SOURCE: FARMLAND INDUSTRIES, INC., DRI, JUNE 1979

be made. In some cases the strip plantings will run at right angles to the spoiling patterns, and in other cases parallel to the pattern. Species planting will be adjusted according to the soil and drainage conditions of the planting area. Mesic species will be planted on the overburden and better-drained sand-clay soils, while more water-tolerant species will be planted in the more poorly drained sand-clay soils. Figure 2-50 depicts the proposed planting program for a reforestation strip crossing a typical sand-clay landfill at right angles to the spoiling program.

Land/Lakes Plantings. The final type of tree planting proposed for the site will be the reforestation of the land areas associated with the lake system created in Sections 2 and 11, T34S, R24E. The entire 70 acres of land will be reforested. As in the other reforestation areas, tree species plantings will be matched with the prevailing soil drainage conditions, i.e., hydric species near the water's edge and mesic species in the upland areas.

In all reforestation plantings on the site, a mixture of transplant sizes will be used. A tree spade will be used to transplant trees of 2-4 inches in diameter from onsite areas that will be mined. The majority of the tree plantings will be made with potted or bare-root seedlings obtained from the Florida Forest Service. A planting density of approximately 200 trees per acre is planned. Cattle will be excluded from the reforestation areas until the transplanted trees have become firmly established. It is expected that the transplanted trees, especially the larger tree-spaded specimens, will serve as seed sources for eventual natural reforestation to a higher density.

2.6.6 WETLAND RESTORATION METHODOLOGY

The types of wetland restoration planned for the Farmland mine site are listed in Table 2-14 and shown in Figure 2-43. Physical and revegetative techniques planned for use in each of these restoration areas are discussed in the following sections.

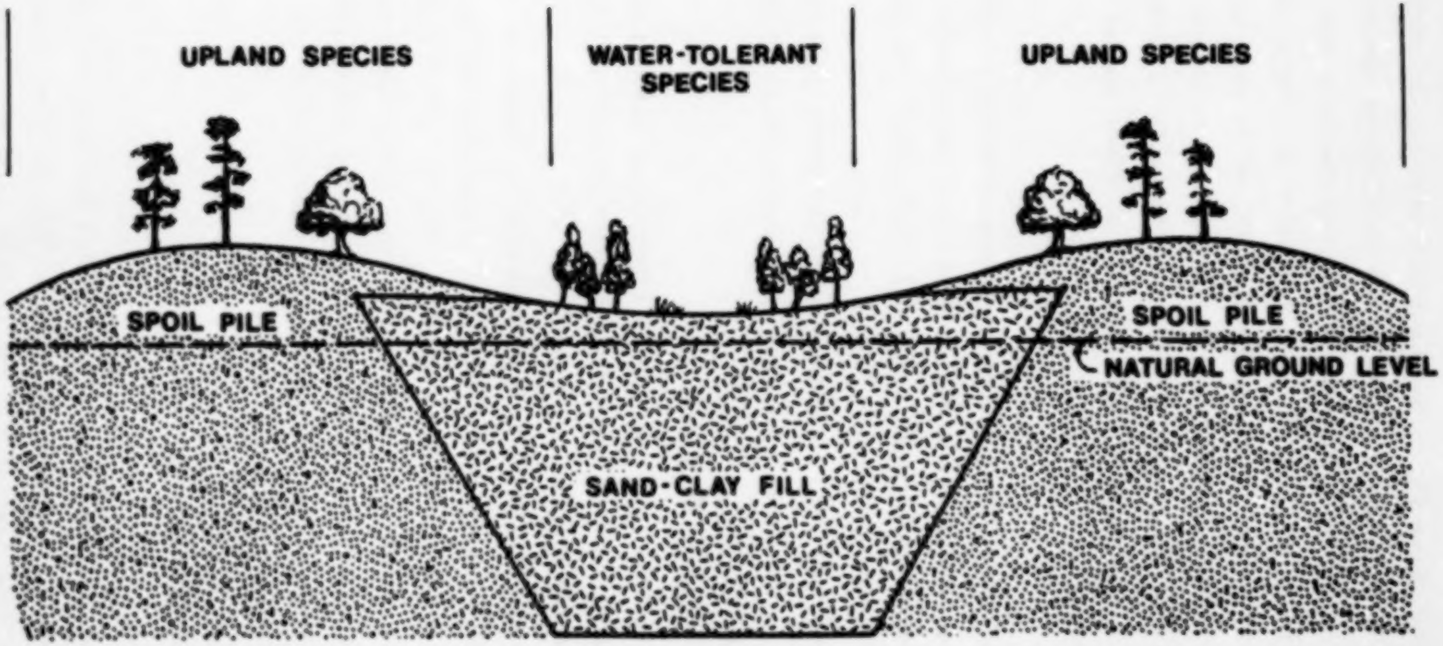
UPLAND SPECIES
WATER-TOLERANT SPECIES
UPLAND SPECIES
SPOIL PILE
SPOIL PILE
NATURAL GROUND LEVEL
SAND-CLAY FILL

FIGURE 2-50. STRIP REFORESTATION AT A TYPICAL SAND-CLAY LANDFILL, MADE AT RIGHT ANGLES TO THE SPOILING PATTERN.

SOURCE: FARMLAND INDUSTRIES, INC., DRI, JUNE 1979

Special Sand-Clay Mix Areas 1 and 2

In two of the sand-clay landfills adjoining the western portion of Oak Creek Islands, special techniques are planned to restore wetland environments through which Oak Creek and one of its northern tributaries will be rerouted. During active mining of these areas the water flow through each of these areas is to be diverted into previously prepared channels outside the mining area. After mining, levees (approximately 11 feet high) are to be constructed around the areas and sand-clay mix introduced to an average height of about 6 feet above natural grade. To speed up the subsidence and thereby allow reclamation to proceed at a more rapid pace, thickened clays dredged from Settling Area 1 will be used in the sand-clay mix for these areas. Subsidence is expected to bring these special mix areas to near original grade on the average, but greater subsidence (where the sand-clay fill is the thickest) is expected to occur in the center of the filled mining cuts so that they will be slightly below grade (see the preceeding Figure 2-49). This gradually sloping land around the protruding spoil piles should create a broad swale approximately 150 feet wide which resembles a natural floodplain. In order to create a meandering floodplain for each of the restored creek channels spoiling patterns are planned to run east-west in Special Mix Area 1 and north-south in Special Mix Area 2. The spoil piles are to be graded to approved slopes and the entire area revegetated prior to introduction of flow-through water into the areas. Graded spoils are to be reforested with mesic species. As shown in Figure 2-49, plantings of hydric trees such as bald cypress and blackgum are planned along the margins of the sand-clay fill while marsh-type vegetation is planned for the lower interior portions.

Shallow Depressions in Sand-Clay Landfills

In filling sand-clay mix areas, the fine clay particles are expected to remain in suspension longer than the sand and coarse clay particles. The areas downslope from the waste inlet are, therefore, expected to be relatively higher in fine clay content. Consequently, these areas should tend to subside more than the rest of the landfill and, unless corrected by stage filling or grading of spoils, form areas where ponded water will stand for a significant portion of the year.

Figure 2-51 provides a conceptual view of the planned marsh restoration in sand-clay landfills. A similar phenomenon typically occurs in conventional clay settling areas. In general, the area of hydric influence is expected to be within the final parallel mining cut in a specific sand-clay mix area, although the area subject to inundation can be made larger or smaller according to the engineered elevation of the outfall. It is currently planned that approximately 5 percent of the total area in sand-clay landfills will be within the area of hydric influence. Since these depressions will be located at the downslope end of the sand-clay landfills, drainage will be directed naturally through them, and thereby provide the hydrological conditions for wetland restoration areas.

It is fully anticipated that these hydric areas will be colonized by wetland species such as cattails (*Typha* spp.) and smartweed (*Polygonum* spp.). Such natural colonization has been demonstrated in the existing mining areas of Polk and Hillsborough Counties. If an acceptable wetland community does not volunteer, plantings, water level adjustments, and soil constituency manipulations will be used to establish desirable wetland vegetation. Specific measures to be used in these wetland revegetation programs will be influenced by the results of the current research being conducted in the phosphate field as well as onsite wetland revegetation research planned for Sand-Clay Area 1.

Littoral Zones in Reclaimed Lakes

Extensive littoral zones will be created by grading of spoils around the designed lake outfalls in the large lake system in Sections 34 and 35, T34S, R24E, while smaller littoral zones will be created along the margins of the two smaller lake systems. Littoral zones will be designed to average approximately 3 feet in depth and not to exceed 6

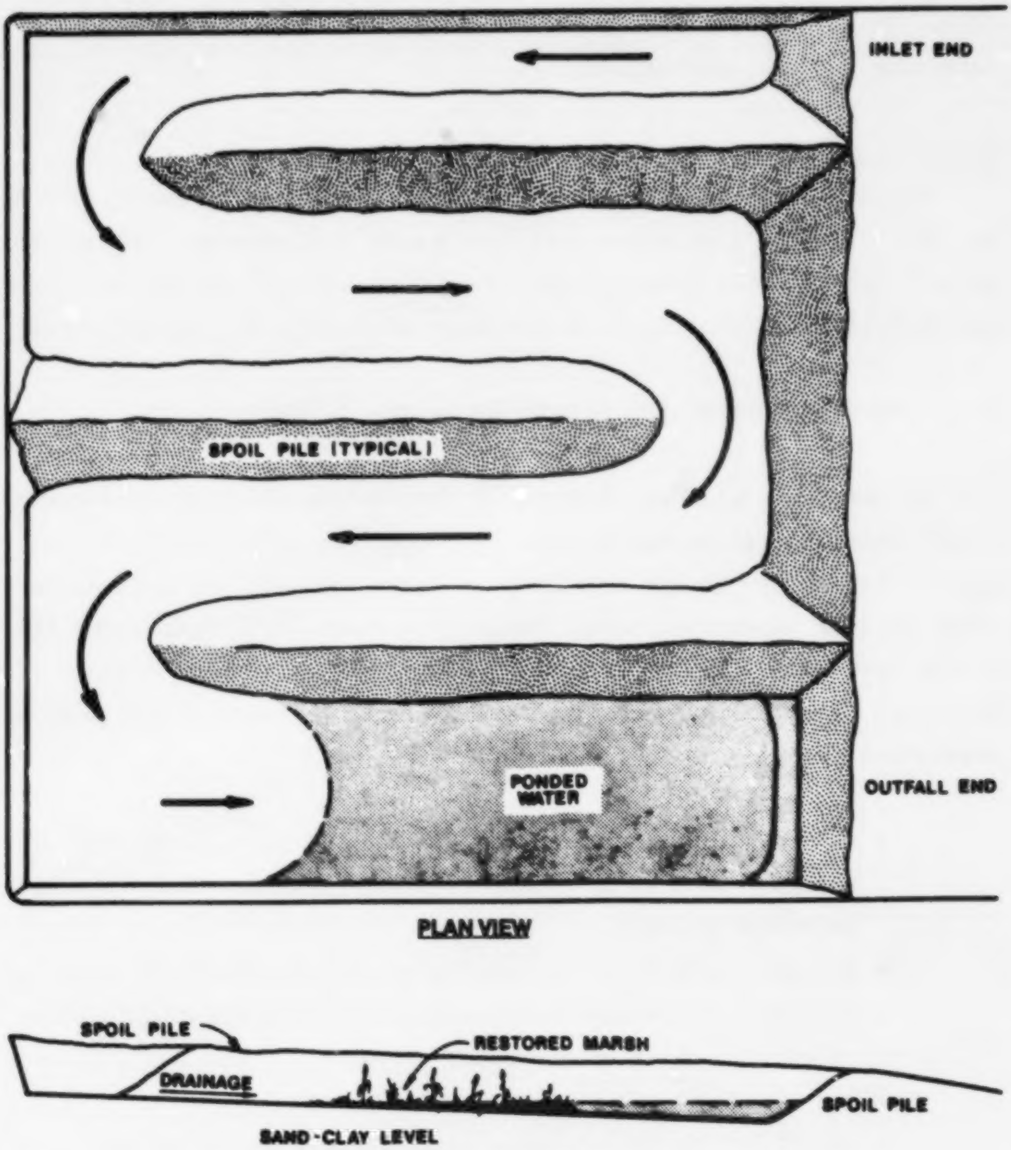
INLET END
SPOIL PILE (TYPICAL)
PONDED WATER
OUTFALL END
PLAN VIEW
SPOIL PILE
RESTORED MARSH
DRAINAGE
SPOIL PILE
SAND-CLAY LEVEL
CROSS-SECTION

FIGURE 2-51. CONCEPTUAL VIEW OF MARSH RESTORATION IN A SAND-CLAY LANDFILL.

SOURCE: FARMLAND INDUSTRIES, INC., HARDEE COUNTY MASTER PLAN, JUNE 1979

feet in total depth. Like the shallow depressions in sand-clay landfills, it is expected that the littoral zones will be naturally colonized by wetland vegetation.

Hydric Areas Along Lake Edges

The upland areas associated with the lake system in Sections 2 and 11, T35S, R24E will be reforested with mesic tree species. Along the water's edge in this lake system, trees such as bald cypress and blackgum will be planted to begin development of a strip of hydric forest.

2.6.7 EROSION CONTROL AND PREVENTION OF TURBID RUNOFF

As presently planned, control of erosion and prevention of turbid runoff into natural stream courses on the mining site will be accomplished primarily through vegetative means. The existing vegetative cover will be maintained in all areas not immediately required by the mining operation. In particularly sensitive areas, one or more of the following measures may be utilized to promote the rapid development of vegetative cover:

- use of seedling mixtures of rapid-germinating temporary forages, such as millet or rye, with the slower-to-establish permanent grasses
- use of supplemental irrigation on plantings made in the dry season to encourage the establishment of a vegetative cover before the onset of the rainy season
- use of sod to establish an immediate vegetative cover
- use of hay or commercial mulches to provide a temporary soil cover while planted vegetation is becoming established

Reclamation plans for the site include reinstituting a drainage system that will be capable of handling runoff without causing erosion in drainage conveyances or the entrance of turbid runoff into the natural streams. Most of the major drainage courses on the site are included in preserved areas. In cases where existing stream channels will be disturbed, both the temporary diversion channels and the final restoration channels will be constructed and revegetated with adequate time allowed before water is introduced into these channels. The reclamation plan also provides for the restoration of marsh areas at the outlets of the sand-clay landfills. All runoff from these landfills will filter through the marsh areas before entering the natural drainage courses.

2.7 REFERENCES

Cape, J.J. 1979. Adapted from figures on file at Woodward-Clyde Consultants, Clifton, New Jersey.

Environmental Science and Engineering, Inc. 1978. Data on file at Farmland Industries, Inc., Mulberry, Florida.

Environmental Science and Engineering, Inc. 1979. Data on file at Farmland Industries, Inc., Mulberry, Florida.

Farmland Industries, Inc. 1979. Development of Regional Impact Application for Development Approval.

Farmland Industries, Inc. 1979. Hardee County, Master Mine Plan.

Zellars-Williams, Inc. 1978. Data on file at Farmland Industries, Inc., Mulberry, Florida.

Zellars-Williams, Inc. 1979. Data on file at Farmland Industries, Inc., Mulberry, Florida.

Table 2-1. PHOSPHATE ROCK PRODUCT SPECIFICATIONS,[1] FARMLAND INDUSTRIES, INC. PROJECT, HARDEE COUNTY, FLORIDA.

	%
BPL	68.65
P_2O_5	31.42
CaO	47.90
F	3.40
Fe_2O_3	1.34
Al_2O_3	0.89
SiO_2 (Reactive)	1.60
SiO_2 (Total)	5.36
Insol	3.76

[1] Preliminary.

Table 2-2. ESTIMATED MINE CONSTRUCTION EXPENDITURES, FARMLAND INDUSTRIES, INC. PROJECT, HARDEE COUNTY, FLORIDA.

	$------ 1978
Construction Labor	$11,750,000.
Equipment and Materials	4,206,000.
Subcontract	10,305,000.
Engineering, Supervision, Administration, etc.	28,985,000.
TOTAL	$55,246,000.

Table 2-3. NUMBERS AND EARNINGS OF MINE AND BENEFICIATION PLANT PERSONNEL, FARMLAND INDUSTRIES, INC. PROJECT, HARDEE COUNTY, FLORIDA.

Job Classification	No. of Employees	$ per Year[1]
Operating Labor	327	$2,923,472
Production Supervision		750,625
Maintenance Supervision		286,875
Maintenance Personnel		700,000
Overhead Personnel	37	672,875
TOTALS	364	$5,333,847

[1] All payroll figures are expressed in 1978 dollars.

Table 2-4. SPECIFICATIONS FOR PETROLEUM STORAGE TANKS, FARMLAND INDUSTRIES, INC. PROJECT, HARDEE COUNTY, FLORIDA.

Number of Tanks	Total Capacity (Barrels)	Minimum Spacing	Petroleum Product	Location
1	190	10'-0"	Kerosene	Mine Complex
1	536	10'-0"	Fatty Acid/Fuel Oil Mix	Mine Complex

Table 2-5. WASTE PRODUCTION AND REAGENT USE, FARMLAND INDUSTRIES, INC. PROJECT, HARDEE COUNTY, FLORIDA.

Contaminent	Waste/Reagent Flow[1]	Ratio of Dilution[2]
Waste Clay	6,120 tons/day	7,800 gal/ton
Waste Sand	14,280 tons/day	360 gal/ton
Sodium Hydroxide	5,508 gal/day	9,600 gal/gal
Fatty Acid	3,917 gal/day	13,500 gal/gal
Fuel Oil	5,998 gal/day	8,800 gal/gal
Sulfuric Acid	3,794 gal/day	13,900 gal/gal
Amine	6,242 gal/day	8,500 gal/gal
Kerosene	612 gal/day	86,400 gal/gal

[1] Undiluted.
[2] Water/Waste or Reagent.

Table 2-6. GROUNDWATER WITHDRAWAL SUMMARY, FARMLAND INDUSTRIES, INC. PROJECT, HARDEE COUNTY, FLORIDA.

Source	Amount (mgd)
Surficial Aquifer	0.36
Deep Well	8.83
Potable Well	0.02
TOTAL WATER FROM SUPPLY	9.21

Table 2-7. NON-CONSUMPTIVE AND CONSUMPTIVE USAGE OF GROUNDWATER, FARMLAND INDUSTRIES, INC. PROJECT, HARDEE COUNTY, FLORIDA.

Loss	Total	Non-Consumptive[1]	Consumptive[2]	Percent Consumptive
Product Shipment	0.13	0.045	0.085	65.4
Waste Pebble Moisture	0.01	0.008	0.002	20.0
Tailings Moisture	1.17	1.170	--	0
Clay Adsorption	5.22	0.783	4.437	85.0
Seepage	2.56	2.432	0.128	5.0

[1] Water returns to the surficial aquifer by seepage and/or is retained as interstitial water in the case of tailings and waste pebble.

[2] Lost from the supply by evaporation, retention in waste clay or removal of the product from site.

Source: Zellars-Williams, Inc. 1979.

Table 2-8. ACREAGES DISTURBED BY CONSTRUCTION/OPERATION OF THE FARMLAND INDUSTRIES, INC. PROJECT, HARDEE COUNTY, FLORIDA.

Type of Disturbance	Annual Average	Total
Mining[1]	247.6	4,951
Mine Waste Disposal on Unmined Land[2]	10.9	218
Beneficiation Plant Construction	-	74
Mine Entrance Road and Railroad	-	25
Miscellaneous (ditches, accessways, service areas, etc.)	0.6	12
TOTAL DISTURBED		5,280
TOTAL UNDISTURBED	-	2,530

[1] The overburden will be placed in previously mined cuts, requiring no appreciable additional acreage outside the active mining cut.

[2] Assuming ore beneath Settling Area I is to be mined in final years.

Source: Zellars-Williams, Inc. 1979.
Environmental Science and Engineering, Inc. 1979.

Table 2-9. LAND USE CLASSIFICATION SUMMARY FOR THE RECLAIMED MINE SITE, FARMLAND INDUSTRIES, INC. PROJECT HARDEE COUNTY, FLORIDA.

	Land Use Classifications											
Type of Acreage	Improved Pasture	Citrus	Other Agri-culture	Pine Flatwoods/ Palmetto Range	Coniferous Upland Forest	Hardwood Upland Forest	Mixed Upland Forest	Planted Mixed Forest	Lakes	Fresh-water Marsh	Fresh-water Swamp	Total
Reclaimed Acreage	3,873	*[1]	224[2]	--	--	--	--	550	235	339[3]	59	5,280
Preserved Acreage	456	160	58	354	47	187	276	--	--	107	885	2,530
TOTAL	4,329	160	282	354	47	187	276	550	235	446	944	7,810

[1] A small citrus planting will be included in the experimental plantings in Sand-Clay Mix Area 1.
[2] In reclaimed acreage, "other agriculture" category consists of upland experimental plantings in Sand-Clay Mix Area 1.
[3] Includes 12 acres of experimental wetland restoration in Sand-Clay Mix Area 1.

Source: Zellars-Williams, Inc. 1978.
Environmental Science and Engineering, Inc. 1978.

Table 2-10. PROPOSED RECLAMATION SCHEDULE FOR THE MINING SITE, FARMLAND INDUSTRIES, INC. PROJECT, HARDEE COUNTY, FLORIDA.

Year	Types of Reclamation in Acres					Cumulative Total
	Sand-Clay Landfill	Clay Settling Area	Tailings Landfill	Land & Lakes Area	Other[1]	
Pre-Mining						
1	--	--	--	--	--	--
2	--	--	--	--	--	--
3	--	--	--	--	--	--
4	--	--	--	--	--	--
5	--	--	77	--	--	77
6	--	--	--	--	--	--
7	--	--	--	--	--	--
8	--	--	--	--	--	--
9	236	--	--	--	--	313
10	181	--	--	--	--	494
11	178	--	--	--	--	672
12	269	--	--	--	--	941
13	286	--	--	--	--	1,227
14	168	--	--	--	--	1,395
15	376	--	--	--	--	1,771
16	439	--	27	140	--	2,377
17	283	--	--	--	--	2,660
18	70	--	--	--	--	2,730
19	323	--	--	--	--	3,053
20	238	--	--	--	--	3,291
21	203	--	--	--	--	3,494
22	190	--	--	--	111	3,795
23	256	--	--	427	--	4,478
24	219	--	--	--	--	4,697
25	--	--	--	--	--	--
26	--	--	--	--	--	--
27	--	--	--	--	--	--
28	--	--	--	--	--	--
29	--	--	--	--	--	--
30	--	583	--	--	--	--
TOTAL	3,915	583	104	567	111	5,280

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[1] "Other" includes reclamation of areas disturbed by construction of ore processing and support facilities.

Source: Zellars-Williams, Inc. 1978.

Table 2-11. RECLAMATION SEQUENCE AND ACREAGE FOR SAND-CLAY LANDFILLS, FARMLAND INDUSTRIES, INC. PROJECT, HARDEE COUNTY, FLORIDA.

Landfill	Acreage	Year of Filling	Year Reclamation Completed
Sand-Clay 1	236	4-5	9
Special Mix 1	181	5-6	10
Sand-Clay 2	103	6-7	11
Sand-Clay 3	75	7	11
Sand-Clay 4	269	7-8	12
Sand-Clay 5	286	8-9	13
Sand-Clay 6	168	9-10	14
Sand-Clay 7	192	10-11	15
Sand-Clay 8	78	11	15
Special Mix 2	106	11	15
Sand-Clay 9	310	12	16
Sand-Clay 10	129	12	16
Sand-Clay 11	137	13	17
Sand-Clay 12	146	13	17
Sand-Clay 13	70	14	18
Sand-Clay 14	215	15	19
Sand-Clay 15	108	15	19
Sand-Clay 16	68	15-16	20
Sand-Clay 17	40	16	20
Sand-Clay 18	130	16	20
Sand-Clay 19	203	17	21
Sand-Clay 20	190	17-18	22
Sand-Clay 21	99	18-19	23
Sand-Clay 22	89	19	23
Sand-Clay 23	68	19	23
Sand-Clay 24	161	19-20	24
Sand-Clay 25	58	20	24
TOTAL	3,915		

Source: Zellars-Williams, Inc. 1978.

Table 2-12. IMPROVED PASTURE ACREAGE CREATED THROUGH RECLAMATION OF DISTURBED LANDS, FARMLAND INDUSTRIES, INC. PROJECT, HARDEE COUNTY, FLORIDA.

Physical Restoration Type	Acreage
Sand-Clay	2,931
Clay Settling Area	531
Capped Tailings Fill	104
Land Associated with Lakes	196
Disturbed Natural Ground	111
TOTAL	3,873

Source: Zellars-Williams, Inc. 1978.

Table 2-13. REFORESTED ACREAGE CREATED THROUGH RECLAMATION OF DISTURBED LANDS, FARMLAND INDUSTRIES, INC. PROJECT, HARDEE COUNTY, FLORIDA.

Type	Acreage
1. Special Sand-Clay Mix Areas 1 and 2	
a. Mesic species	143
b. Hydric species	52
2. Strip Planting in Sand-Clay Landfills and Clay Settling Area	344
3. Land Associated with Lakes	
a. Mesic species	63
b. Hydric species	7
TOTAL	609

Source: Zellars-Williams, Inc. 1978.

Table 2-14. WETLAND ACREAGE CREATED THROUGH RECLAMATION OF DISTURBED LANDS, FARMLAND INDUSTRIES, INC. PROJECT, HARDEE COUNTY, FLORIDA.

Type	Acreage
Broad swales in Special Mix Areas 1 and 2 for the rerouting of the western portion of Oak Creek and one of its tributaries.	144
Shallow depressions around the outlet end of all other sand-clay landfills.	181
Littoral zones in portions of reclaimed lakes.	66
Hydric areas along the margin of the reclaimed lake area in Sections 2 and 11, T35S, R24E.	7
TOTAL	398

3.0
METEOROLOGY, AIR QUALITY, AND NOISE

3.1 THE AFFECTED ENVIRONMENT

3.1.1 REGIONAL METEOROLOGY

The Farmland site is located in west central Florida, which has a semitropical climate. Weather conditions are greatly influenced by the area's latitude and by the relatively warm coastal waters surrounding the state. The project site is subject to annual variations in both temperature and precipitation; however, analysis of the data obtained from surrounding stations indicates that the area sustains two general seasonal patterns (winter and summer). Summers are hot and humid; extremely high temperatures are rare due to convective cloud activity and frequent afternoon thunderstorms. Winters are generally mild, with periodic invasions of cool to cold air from the north. Rainfall is abundant, averaging approximately 140 cm (55 inches) for the year. The heaviest rainfall occurs in June, July, August, and September. Very heavy rainfall amounts are associated with tropical storms and hurricanes which occasionally pass through the area during the late summer and fall months. The storms may also cause wind and water damage to crops and buildings.

The following sections provide a more detailed discussion of temperature, precipitation, humidity, wind and other meteorological parameters characterizing local and regional climatic conditions.

METEOROLOGICAL DATA SOURCES

Meteorological data representative of the site are available from a number of local and regional sources. The following is a brief summary of data sources and references employed:

- National Climatic Center temperature data for Wauchula, Lakeland, Tampa, Bartow, Arcadia, and Bradenton.
- National Climatic Center precipitation data for Wauchula, Avon Park, Lakeland, Tampa, Bartow, and Arcadia.
- Rainfall and meteorological data from the University of Florida Agricultural Research Center (ARC) near Ona, Florida.
- Rainfall data for the Farmland site.
- Rainfall Frequency Atlas of the United States.
- Humidity data for Tampa, Lakeland, and Fort Myers, Florida.
- Evapotranspiration data for Lakeland and Tampa, Florida; open pan evaporation rates for Lake Alfred, Florida.
- Wind and stability data for Tampa, Lakeland, and Fort Myers, Florida.
- Mixing height and pollution potential data for the Farmland site region.
- Worst-case meteorology data for Tampa.
- Severe weather and other general climatic data pertinent to the site area.

TEMPERATURE

Temperature data representative of the region and project site area are available for a number of locations surrounding the site. These include Wauchula, Lakeland, Tampa, Bartow, Arcadia, and Bradenton. Table 3-1 shows monthly and annual mean temperatures for these locations. It is readily apparent from these data that there is little variation in monthly and annual temperature mean values for the local area. More detailed temperature records for Wauchula, Tampa, and

Lakeland (Tables 3-2, 3-3, and 3-4), which provide monthly extreme maximum and minimum values, indicate a slightly higher diurnal range at Wauchula, the closest reporting station to the project site. This can be attributed to moderating effects of the nearby coastal waters at Tampa and broader lake influences at Lakeland. These influences are minor and, with the exception of extreme values, long-term records from any of the three locations can be used to characterize the temperature patterns for the project area.

The average annual temperature is approximately 22.5°C (72 to 73°F). The monthly averages range from 16.5°C (62°F) in the winter (January) to 27.8°C (82°F) in the summer (August). Winters are pleasant and characterized by bright warm days and cool nights. Temperatures during the winter are seldom severe; however, major cold waves do overspread the area, occasionally bringing temperatures down to the twenties (°F). Temperatures of -6.1°C (21°F) were recorded at Wauchula during cold waves in December 1962 and January 1981. Frost conditions vary considerably between low and high ground locations. Although the total incidence of freezing temperature is low, a single occurrence lasting more than a few hours can severely damage crops. In a study conducted by Bradley (1974), 17 freezing occurrences were reported at Lakeland between 1931 and 1950. Forty-one occurrences were reported at Arcadia (13 miles southwest of the project site) during the same period.

During the summer season the maximum temperature ranges between the high eighties and mid-nineties, while minimum temperatures usually drop to the low seventies (°F). The maximum temperature reported at Wauchula was 40°C (104°F), while a maximum of 38°C (101°F) was reported at both Tampa and Lakeland. Most afternoon temperatures are moderated by thundershowers; temperatures frequently plunge from the mid-nineties to the low seventies or high sixties (°F) in a matter of minutes during one of these thundershowers.

PRECIPITATION

As in the case of temperature data, precipitation records representative of the region and the project site area are available for a number of locations surrounding the site. These include Wauchula, Avon Park, Lakeland, Tampa, Bartow, and Arcadia. Table 3-5 shows monthly and annual precipitation normals for these locations. Data are also available for the University of Florida's Ona Agricultural Research Center, located within several miles of the Farmland site. Also, field data collected at the Farmland site and at the proposed Estech General Chemicals Corporation Duette Mine in Manatee County are available for limited periods. The inland reporting stations and those closest to the site (Wauchula, Ona, Bartow, and Avon Park) appear to be most representative, reporting annual values of 138.8 to 140.5 cm (54.66 to 55.34 inches). Tampa, closer to the coast, and Lakeland, farther to the north, show annual totals of 125.4 cm (49.38 inches) and 125.5 cm (49.43 inches), respectively.

As noted, rainfall in the study area is abundant, averaging 137 to 139 cm (54 to 55 inches). Seasonal variations are apparent from the data; the heaviest rainfall occurs during the months of June, July, August, and September, with an average of between 18 to 23 cm (7 to 9 inches) falling during these months. November and December, the driest months, average less than 5 cm (2 inches). Occasional tropical storms serve to increase the late summer and early fall amounts, but the frequency of these storms is low and they have little effect on the long-term average annual rainfall.

Table 3-6 shows monthly mean, maximum, and minimum rainfall amounts for Wauchula, while Tables 3-7 and 3-8 show the long-term data for Tampa and Lakeland. The highest annual rainfall reported at Wauchula was 212 cm (83.48 inches) in 1953, while 232 cm (91.57 inches) was reported in 1960 at both Tampa and Lakeland. The highest monthly rainfall reported at Wauchula was 46.7 cm (18.40 inches); maximum 24-hr totals reported at Tampa and Lakeland were 30.7 cm (12.11 inches) and 25.7 cm (10.12 inches), respectively.

Presented below are maximum precipitation amounts projected for the project site (point precipitation) for 24-hr periods and specific recurrence intervals computed using statistical procedures outlined by Hershfield (1961) and Miller (1964). These data appear to be consistent with available long-term data for the area.

	Recurrence Interval					
	1 yr	5 yrs	10 yrs	25 yrs	50 yrs	100 yrs
Maximum 24-hour Point Precipitation (in.)	4.0	6.5	7.8	8.9	9.0	11.0

It is important to note also that the annual average is a statistical summary of precipitation data collected over a period of 30 years or more. Considerable variations can occur from year-to-year or over an extended period of time. For example, during the period 1964 through 1975, precipitation appears to be generally below normal for the project area, with a 1 or 2 year exception (Mississippi Chemical Corporation 1976). Cyclic patterns and significant variations from the "normal" are evident from these data.

While the above data illustrate the need for collecting long-term records in order to characterize weather parameters, shorter term field investigations are frequently used to substantiate the existing data base and to identify current trends. Rainfall was monitored at three rain gauges on the Farmland site from June 1977 through August 1978. Historically, including 1977 and 1978, the wet season rainfall (June through September) amounts to approximately 60 percent of the yearly total, with the rest divided among the remaining 8 months. Since most of the wet season rainfall comes from thunderstorms and related tropical weather forms, there is typically intense rainfall of short duration with a high percentage of runoff. The dry season precipitation is usually associated with frontal systems moving through the area, with slower rainfall rates allowing a greater percentage of infiltration.

The average total rainfall on the property during the 1977-1978 rainfall year was about 140 cm (55 inches). This is very close to the long-term average for the area, although data from the University of Florida Agricultural Research Center (ARC) at Ona during this same period reported a total rainfall amount of approximately 150 cm (59 inches) during this same period. Nevertheless, the field program does indicate that the long-term data are entirely representative of the project site.

HUMIDITY AND FOG

As would be expected in an area of high rainfall and subtropical temperatures, central Florida's humidity also is moderate to high. Humidity data are only available on a long-term basis from major reporting stations. Table 3-9 indicates the monthly highs and lows for Tampa and Fort Myers. The highest humidity usually occurs around dawn, with the lows occurring in the early afternoon. Associated with the humidity is the occurrence of ground fog, which is observed most often during the winter (Bradley 1974). Most heavy fog dissipates rapidly after sunrise and is gone before noon. The average number of days with fog for Tampa, Lakeland, and Fort Myers is also shown in Table 3-9.

EVAPOTRANSPIRATION

The meteorological conditions resource document for the Estech General Chemicals Corporation Duette Mine EIS (U.S. EPA 1979a) has evaluated evapotranspiration for a location in close proximity to the Farmland site. This evaluation, which is presented below, is also pertinent to the Farmland site.

> "Water is lost to the atmosphere through evapotranspiration from soils and vegetation and evaporation from open water surfaces. The actual evaporation/transpiration (ET) rate can be determined by several different methods. A simple and commonly used method employs the concept of water balance. Accurate measurements are made of precipitation, runoff, and groundwater recharge. The water which cannot be accounted for in either the runoff or recharge is the ET rate. The Southwest Florida Water Management District (SWFWMD) cites this rate at 39 in./yr (Water Crop 1977) based on a study by Cherry, Stewart, and Mann (1970). A more recent study by Dohrenwend (1977) states a potential evaporation rate of 45.23 in. for Tampa, with the actual rate being 34.84 in. The potential evaporation rate is the rate which would occur if sufficient moisture were available at all times.
>
> Using the ET rate of 39 in./yr the ET/Precipitation ratio for Lakeland is 0.78 and for Tampa is 0.80. Using the more recently developed rate of 34.84 in. these ratios are 0.70 and 0.72 for Lakeland and Tampa, respectively. These calculations are based on the mean annual precipitation reported by NOAA (Local Climatological Summaries).
>
> In order to obtain evaporation rates the U.S. Weather Bureau uses a U.S. Weather Bureau Class A Land Pan, which is 4 ft in diameter and 10 in. deep. The water surface is maintained 2 to 3 in. below the rim of the pan. Inasmuch as the rate of evaporation from small areas is greater than that from large areas, a pan coefficient of 0.70 has been recommended for converting observed open pan evaporation values to an estimated value for lakes or reservoirs (Chow 1964). The U.S. Weather Bureau uses a coefficient of 0.77.
>
> The nearest measurement station in southwest Florida is Lake Alfred, an agricultural experiment station located approximately 10 miles east of Lakeland. Recent "open pan" evaporation rates for this station are summarized in [Table 3-10]. The measurements are slightly higher than the 60 to 65 in. reported for the area by the U.S. Weather Bureau (1959). The same U.S. Weather Bureau report lists an annual average lake evaporation rate of 50 to 52 in./yr, with 60 to 62 percent occurring from May through October."

METEOROLOGICAL DISPERSION DATA

The ability of the atmosphere to disperse air pollutants emitted into it at a particular location depends on a number of atmospheric variables, the most important of which are stability characteristics, wind direction and speed frequency distributions, mixing depth, and various combinations of these parameters. Only limited site-specific dispersion data are presently available for the Farmland site. However, meteorological assessment can be made on the basis of local and regional data. Because the surrounding terrain is almost flat, regional meteorological data for wind, stability, and mixing height appear appropriate for characterizing the dispersion conditions at the site.

Wind Direction and Speed

Long-term regional data are available for Tampa, Lakeland, and Fort Myers to describe wind direction and speed in the Farmland site area. The average wind speeds and directions for these locations are presented in Table 3-11. Considerable variation is evident for different seasons of the year and also with respect to the proximity of stations to the coast. Daily wind patterns near the coast are dominated by land-sea breezes and speeds are generally slightly higher in magnitude than winds further inland. Nevertheless, broad regional influences are evident with a predominant northerly component during the fall and winter months, and an easterly or southerly component (inland) during the summer months.

Seasonal summaries of wind data for limited periods are available for Lakeland and Tampa (1942 to 1945 for Lakeland; 1965 to 1969 for Tampa), see Tables 3-12 and 3-13. Wind roses showing relative distribution frequencies for Lakeland and Tampa are presented by EPA (1979a). These clearly indicate differences in the wind distribution patterns for the two areas. The Lakeland data demonstrate a major influence from the tradewinds and the passage of frontal system through the area. During the spring and summer months the winds are from the east and south. During the fall and winter there is a shift to a much more northerly direction (NOAA undated).

The most comprehensive wind data for dispersion modeling are those recorded at Tampa. Although the site may exhibit more pronounced "inland" wind patterns (as compared to Tampa), predominant 3-hr and 24-hr wind and stability characteristics employed in worst-case dispersion calculations should be essentially the same for the site as the profiles obtained from the Tampa long-term data. Annual and seasonal wind roses for Tampa are presented in Figures 3-1 through 3-5.

While data from nearby cities such as Tampa and Lakeland can be used to generally describe the wind speed/direction variation expected at the Farmland site, data have been presented by the IFAS of the University of Florida (IFAS 1980) which suggest that important data are not included in these data bases, specifically, the occurrence of low wind speeds (<2.3 miles/hr). These data are not available because the stall speed of the Tampa anemometer is 2.3 miles/hr. It is the National Weather Service's policy to code all winds less than 2.3 miles/hr as calm, and to ignore the direction of winds less than 2.3 miles/hr. The IFAS report indicates that it is these winds that would cause pollutants trapped by an inversion to drift slowly in the stable layer and accumulate over a relatively small area.

Atmospheric Stability

Pasquill stability classes are useful tools for describing the atmosphere's capability to disperse air pollutants and are relied upon for atmospheric modeling. The stability classes are determined from the intensity of incoming solar radiation, percent cloud cover, cloud ceiling, and surface wind speed. The stability classes are described as follows:

Class	Definition
A	Extremely unstable (extreme afternoon turbulence)
B	Unstable
C	Slightly unstable
D	Neutral (turbulence virtually absent - conditionally unstable)
E	Slightly stable
F	Stable to extremely stable (atmospheric stratification)

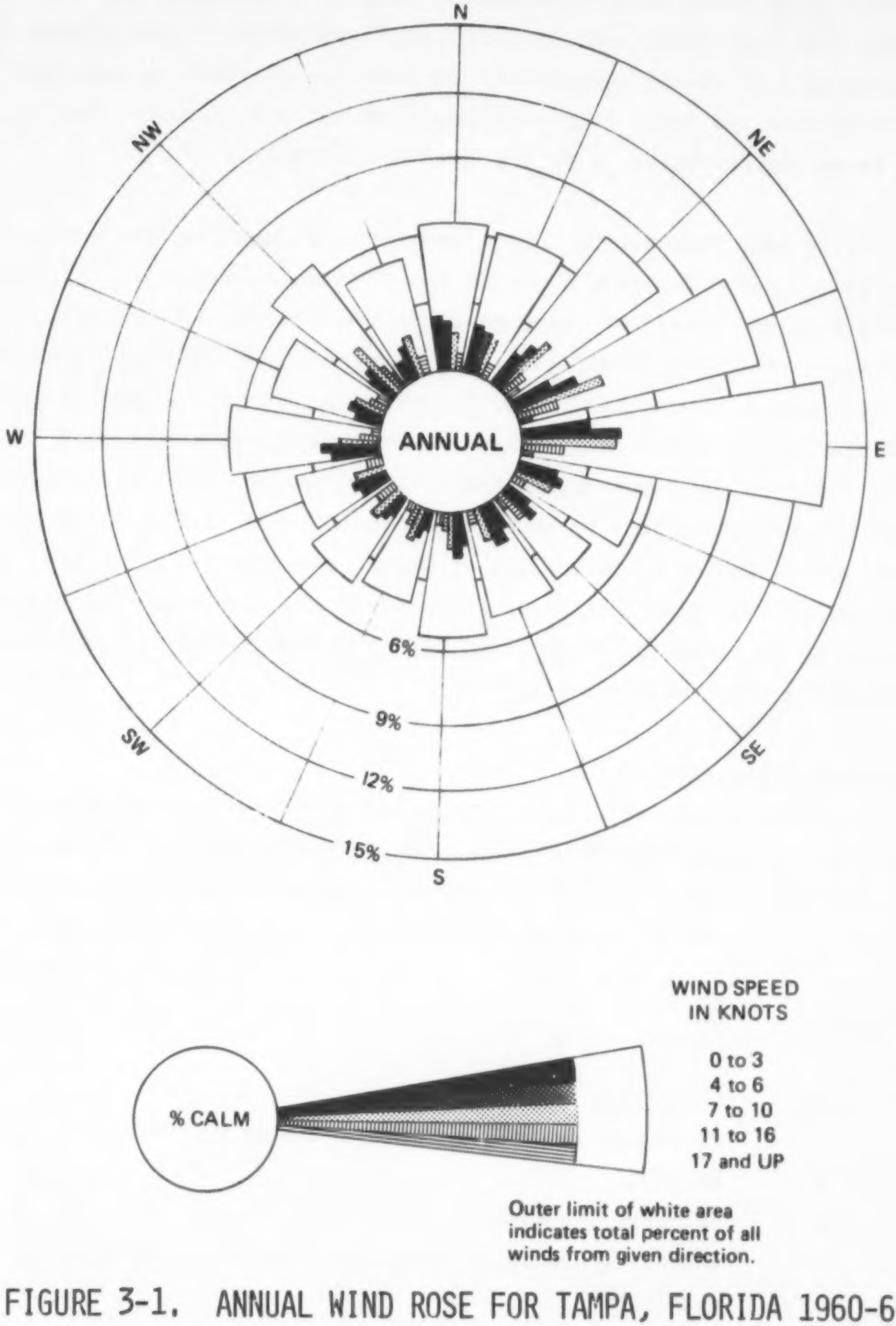


FIGURE 3-1. ANNUAL WIND ROSE FOR TAMPA, FLORIDA 1960-64.

SOURCE: STAR Wind Data (1960-64).

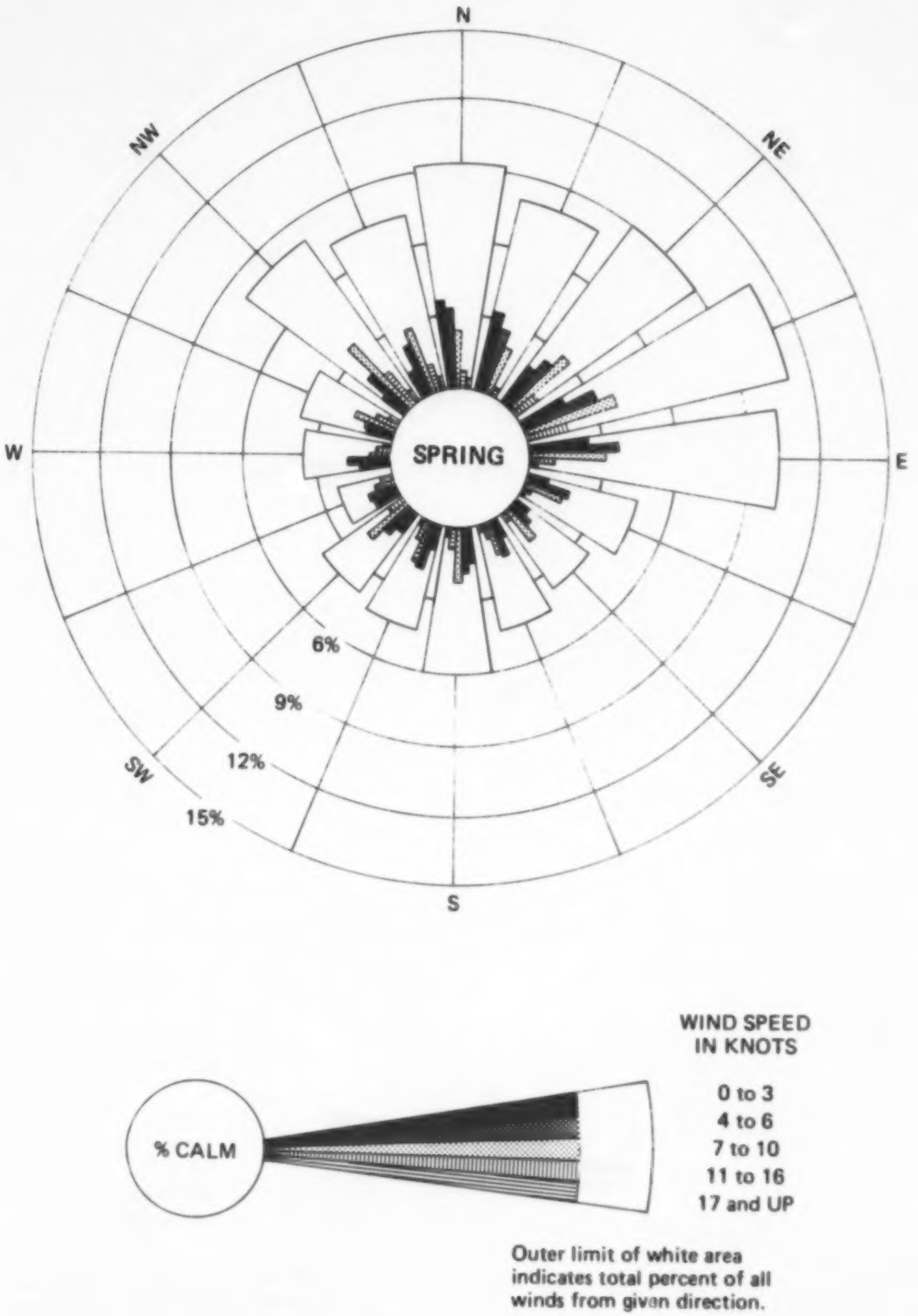
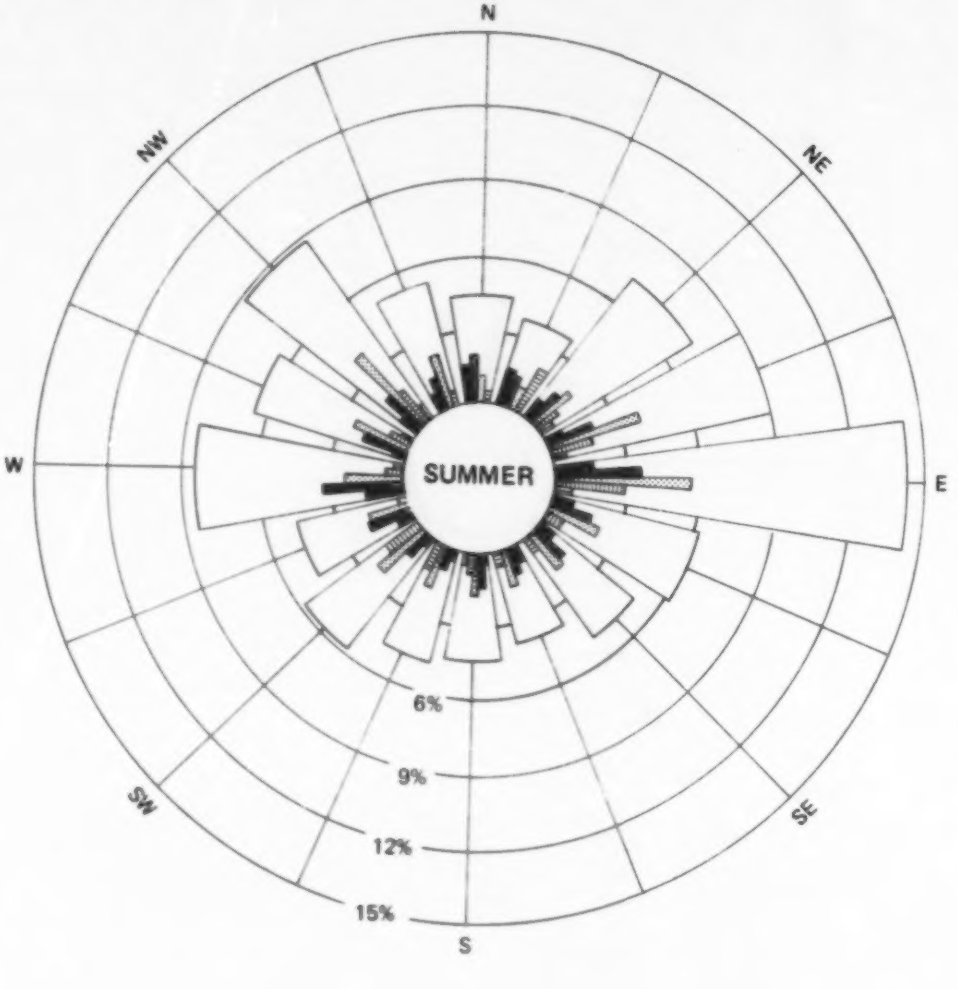
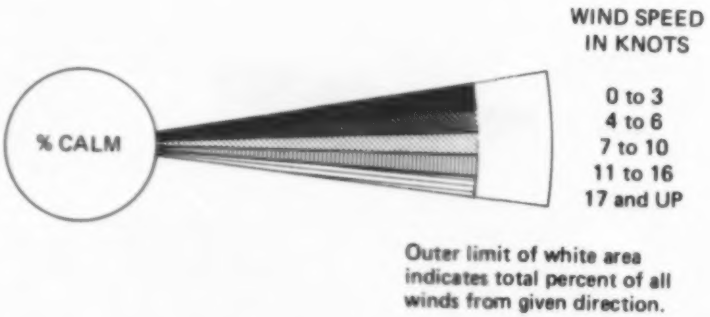


FIGURE 3-2. SEASONAL WIND ROSE FOR SPRING AT TAMPA, FLORIDA; 1960-64.

SOURCE: STAR Wind Data (1960-64).

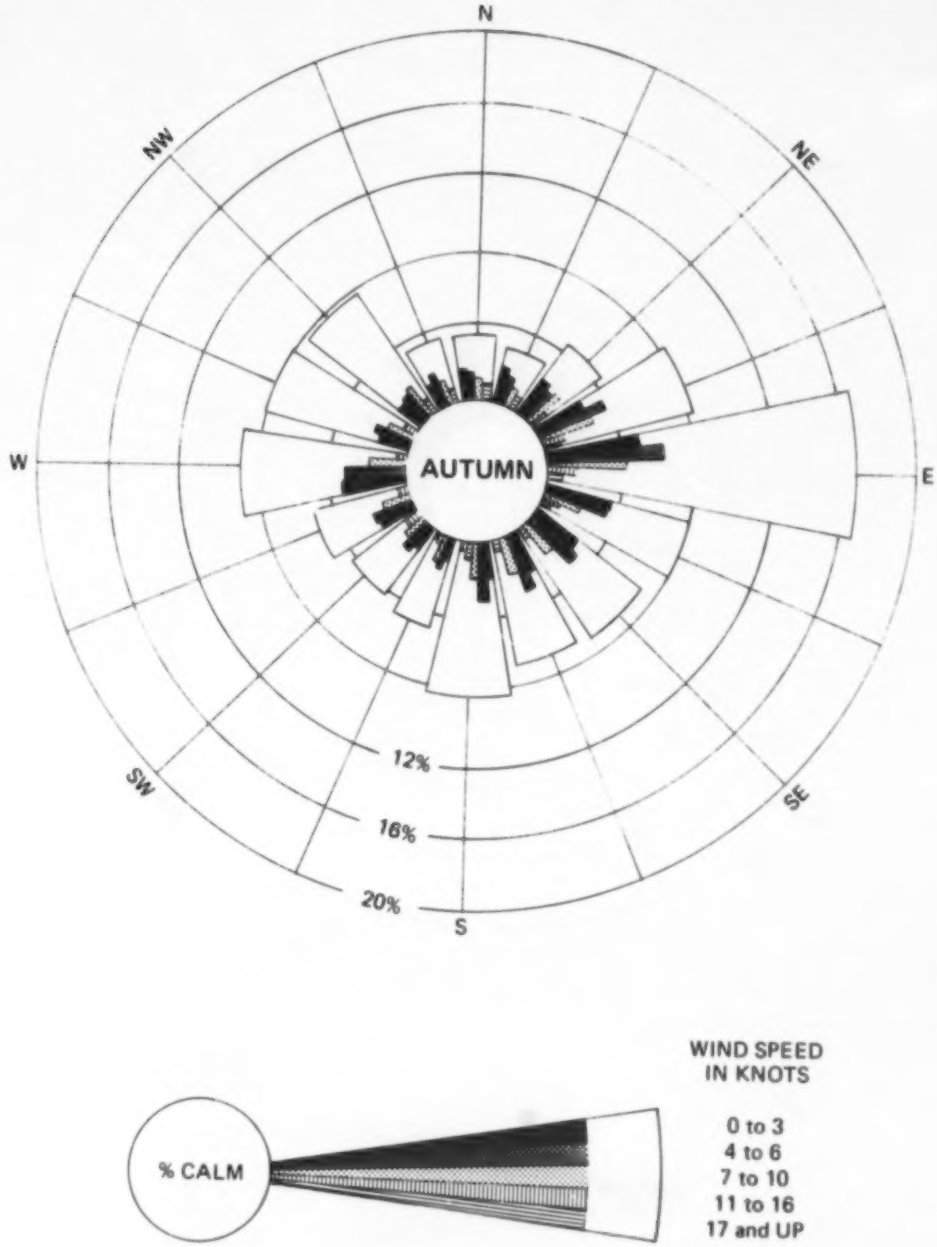


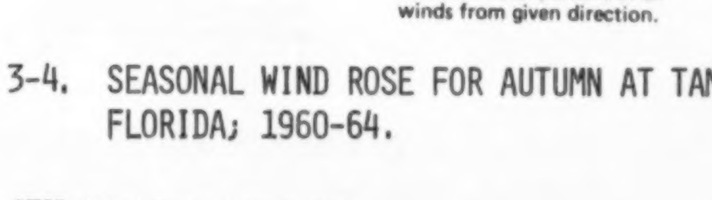

WIND SPEED
IN KNOTS
% CALM
0 to 3
4 to 6
7 to 10
11 to 16
17 and UP

Outer limit of white area indicates total percent of all winds from given direction.

FIGURE 3-3. SEASONAL WIND ROSE FOR SUMMER AT TAMPA, FLORIDA; 1960-64.

SOURCE: STAR Wind Data (1960-64).

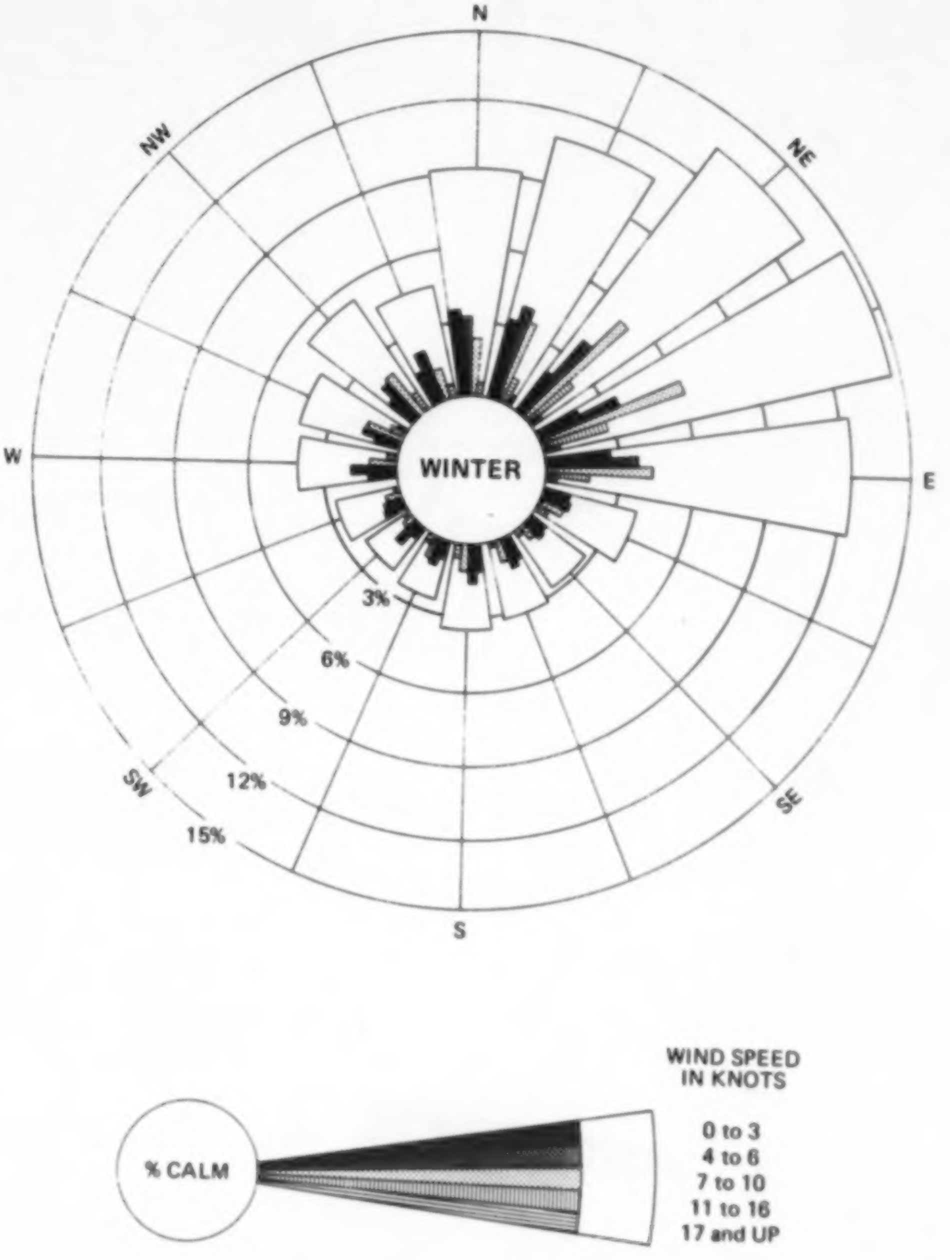



WIND SPEED
IN KNOTS
0 to 3
4 to 6
7 to 10
11 to 16
17 and UP
% CALM

Outer limit of white area indicates total percent of all winds from given direction.

FIGURE 3-4. SEASONAL WIND ROSE FOR AUTUMN AT TAMPA, FLORIDA; 1960-64.

SOURCE: STAR Wind Data (1960-64).



Outer limit of white area indicates total percent of all winds from given direction.

FIGURE 3-5. SEASONAL WIND ROSE FOR WINTER AT TAMPA, FLORIDA; 1960-64.

SOURCE: STAR Wind Data (1960-64).

Table 3-14 summarizes NOAA data annually and seasonally by stability class for Tampa from 1965 through 1969. Classes E and F are combined.

Mixing Depth and Ventilation Factors

The mixing depth is the depth above the surface through which relatively vigorous vertical mixing occurs based upon the dry adiabatic lapse rate. The ventilation factor is the mixing depth times the average wind speed through the mixing depth. The cubic meters (m^3) of air available for dilution can be determined from this factor by multiplying it by the distance transversed. Table 3-15 lists mean seasonal mixing depths, mean wind speed through the mixing depth, and ventilation factors for Tampa (NOAA 1968). These were calculated from non-precipitation events, as the assumption of a dry adiabatic lapse rate in the mixing layer becomes questionable when precipitation occurs (Holzworth 1972). A mixing depth of 150 m or less occurred 15.7 percent of the time from 1960 through 1965. The greatest occurrence of these low mixing depth conditions can be expected from October through May. A mixing depth of less than 120 m can be expected about 10 percent of the time (NOAA 1968). The average morning mixing depth is 493 m for non-precipitation cases with an average wind speed of 5.3 m/sec. The average afternoon mixing depth is 1359 m for non-precipitation cases, with an average wind speed of 7.8 m/sec (Holzworth 1972).

Episode Occurrence Frequency

The U.S. Environmental Protection Agency (EPA) defines episode (stagnation) conditions to exist when the mixing depth is less than 1500 m with an average wind speed through the mixing depth of less than 4 m/sec. Table 3-16 summarizes the occurrence of episode conditions for Tampa from 1960 through 1964. There were approximately two times per year when episodes exceeded 2 days; those of 3-day duration occurred about once every 2 years (NOAA 1968).

Typical and Worst-case Meteorology

Annual (typical) conditions are generally determined using joint frequency distributions of wind speed, wind direction, and stability. A regional assessment indicates that the wind speed and stability parameters are reasonably uniform over the central Florida area. The mean long-term wind speed at Lakeland is 3.1 m/sec and should be close to the mean wind speed at the project site. The mean wind speed at Tampa over the long-term is slightly higher, 4 m/sec, reflecting a moderate sea breeze influence. On the other hand, the stability data for Tampa should be closely representative of the project area. With respect to wind direction, one may anticipate that the distributions for Tampa will show more pronounced east-west directional components reflecting the land-sea breeze influence, while the project site will show a more variable distribution similar to Lakeland. It is particularly noteworthy that Lakeland data show a very broad distribution of wind direction with the largest component being 11 percent from the northeast (see Table 3-13).

The most readily available long-term data for west central Florida are from Tampa. Wind and stability characteristics for Tampa are periodically summarized through NOAA's STAR program and the EPA CRSTER preprocessor program. A recent summary (1971 through 1975) contains joint frequency analyses of these data. Other distributions, such as the 1965 through 1969 STAR program data, present both annual and seasonal summaries.

In applying the Tampa data to the project site, consideration should be given to local differences in order to arrive at a site-specific interpretation. As noted, some differences do exist (on an annual basis), and a precise comparison can only be made when site-specific meteorological data are available and are utilized. Nevertheless, the relative consequences of employing the Tampa data may be readily assessed. For example, one would anticipate slightly higher ambient concentrations at the project site because of lower mean annual wind speeds; on the other hand more variable wind directional distributions at the site would result in better annual dispersion and somewhat lower concentrations on an annual basis. This could result in very close to a trade-off with respect to maximum annual concentrations at the project site.

SEVERE WEATHER

Macroclimatic hazards include storms of hurricane intensity (winds of 74 mph or greater), tornados, hailstorms, and severe thundershowers. The effects of severe weather hazards on the project site area are discussed below.

Tropical Cyclones

A hurricane is a tropical cyclone with winds of 74 mph or higher. These cyclones usually occur in tropical waters during the summer and fall. The Keys hurricane of September 2, 1935, was the most violent ever recorded. It has been estimated that this hurricane had sustained winds in excess of 200 mph (Dunn 1967). The probability of a hurricane striking Tampa during any given year is 1 in 20 (there is less probability of inland areas being exposed to hurricane force winds); however, no area in Florida is immune to these storms. The intense rains associated with hurricanes usually cover a much broader area than the winds and would undoubtedly affect the proposed mine site if a hurricane were to strike the Tampa Bay region. Precipitation associated with hurricanes is normally from 5 to 10 inches, depending on the speed of the hurricane. An example of these heavy precipitation events is noted for Fort Meade, an inland area near the proposed mine site, where 14.5 inches of rain was recorded in September, 1903, in association with a hurricane (Dunn 1967). Long-term data indicate that between 1901 and 1955, 17 tropical storms resulted in some destruction in the vicinity of the proposed site (Bradley 1974).

Tornados

Tornados can occur anywhere in Florida. Lakeland and the proposed mine site lie within a 1° square which had a total of 43 tornados between 1955 and 1967. During this same period the greater number of tornados occurred in the month of June (Pautz 1969).

Hailstorms

The west central region of Florida does not frequently experience hailstorms; however, they do occur. The proposed mine site lies within a 1° square which had a total of nine hailstorms with 3/4-inch hail or greater for the period 1955 through 1967 (Pautz 1969).

Wind Storms

The proposed mine site lies within a 1° square which had 19 wind storms of 50 knots or greater during the period 1955 through 1957 (Pautz 1969). The mean recurrence interval for maximum wind speeds (mph) 30 feet above the ground for the project site area is as follows:

	Interval (yrs.)			
	2	10	50	100
Maximum Wind Speed (mph)	52	65	88	100

Thundershowers

Tampa has about 90 days per year with thundershower activity and Lakeland has about 100. These showers occur mostly during the rainy season. The showers are often short, lasting only an hour or two during the late afternoon and evening hours. The more severe thundershowers are sometimes accompanied by hail or locally strong winds which may inflict serious damage to crops and property (Bradley 1974).

3.1.2 AIR QUALITY STANDARDS

The proposed Farmland mining operations are required by local, state, and Federal laws to comply with a number of air quality regulations.

The State of Florida Department of Environmental Regulation (FDER) and the EPA currently both have review and permitting authority for new sources of air pollution in Florida. The new source review process performed by these regulatory agencies insures that all applicable regulations will be met and that appropriate steps will be taken to minimize atmospheric emissions.

EMISSION SOURCES WITHIN 50 KILOMETERS

Sulfur Dioxide

Major SO_2 emission sources are not located in the immediate area of the Farmland site. The nearest such source is American Orange, located about 10 km from the site in Wauchula. The site is located approximately 35 km south of the Polk County phosphate mine district, which has several major SO_2 sources. The Florida Power and Light (FP&L) Manatee Power Plant is located approximately 50 km northwest of the proposed site. Several major Hillsborough County SO_2 emission sources, including Tampa Electric Company's Big Bend Power Plant and the Gardinier, Inc. phosphate fertilizer complex, are located no closer than 60 km northwest of the proposed site. A few other minor sources of sulfur dioxide are located in Hardee County (Wauchula and Zolfo Springs), and in DeSoto and Highlands Counties.

Particulate Matter

The majority of the SO_2 sources listed above are also emission sources of particulate matter. There are no major particulate emission sources in the immediate area. The major sources within the Polk County phosphate mine district are approximately 35 km north of the site; the major Hillsborough County particulate matter sources are approximately 60 km northwest of the site.

AREAWIDE POLLUTANTS OF CONCERN

The major industrial sources of pollutants in the region are from electric utilities and the phosphate industry. Among the primary pollutants associated with the phosphate industry are SO_2, TSP, and insoluble fluorides. EPA (1978) reports that these result from the following phosphate industry activities:

"• SO_2 originates primarily from the burning of sulfur containing fossil fuels and the manufacture of sulfuric acid from elemental sulfur (Pedco 1976a; EPA 1977).

- TSP is generated by fuel-burning, drying, grinding, and material transport, as well as by some stages of mining (Pedco 1975; 1976a, 1976b).

- Fluorides arise from various chemical processes, drying and calcining, fluoride removal for feed preparation, and gypsum and cooling-water ponds (ESE 1977a; Tessitore 1975; 1976)."

EPA (1978) summarizes point and area sources emissions over a seven county area in west central Florida. From these data it is noted that Hillsborough point sources are dominated by the power industry, while Polk County point sources are dominated by the phosphate industry. Emission sources in Manatee County are low to moderate (with some utility and phosphate industry activity), while emission sources in the surrounding Counties of Charlotte, DeSoto, Hardee, and Sarasota are relatively insignificant. In the industrial counties (Polk and Hillsborough) point sources dominate; for the other five counties, area sources dominate.

AMBIENT AIR QUALITY DATA

Representative regional information and data from a number of proposed activities in close proximity to the site are available. These include data from the CF Mining Corporation (CF) site in northern Hardee

County (14 km from the Farmland site), the proposed Estech General Chemicals Corporation (Estech) Duette Mine in eastern Manatee County (about 18 km from the Farmland site), and a proposed Mississippi Chemical Corporation (MCC) mine site located adjacent to the Farmland site. Data are also available from Sarasota County air monitoring stations at Sarasota, Florida. Ambient air quality measurements have also been obtained on the Farmland site by Environmental Science and Engineering, Inc. (ESE). These studies include monitoring programs (begun in January 1979) for SO_2, TSP, and fluorides. The Standard Operating Procedures used in these programs meet the requirements for PSD ambient air monitoring as described in 40 CFR 58, Appendix B. The methods used by ESE, including quality assurance procedures, are described by ESE (1979). The locations of air monitoring stations at or in close proximity to the proposed Farmland mine site are shown in Figure 3-6.

Sulfur Dioxide

A summary of available SO_2 data for the CF program as well as the Sarasota County station is provided in Table 3-17. A summary of SO_2 data collected for 1 year between 1977 and 1978 at the Estech site is shown in Table 3-18.

Data from September 1976 through September 1978 are presented for the Sarasota County station. This station is a rural, remote, background monitoring station with no significant sources of pollutants located nearby. All samples were obtained utilizing a West-Gaeke temperature controlled bubbler on a once-every-sixth-day schedule. The data reflect very low SO_2 levels at this site. Average levels were less than 10 $\mu g/m^3$. After consulting with Sarasota County, the surprisingly high maximum 24-hr values of 60 $\mu g/m^3$ and 41 $\mu g/m^3$ were attributed to an unknown local influence, and not to any point sources of sulfur dioxide in the region.

The eight-station CF monitoring network includes seven continuous monitors and one bubbler monitor (AQ-3) operating on a once-every-sixth-day schedule. Because of the form of the data and due to the minimum detectable limits of the monitoring devices being reached quite frequently, annual average SO_2 values were not derived. However, scanning

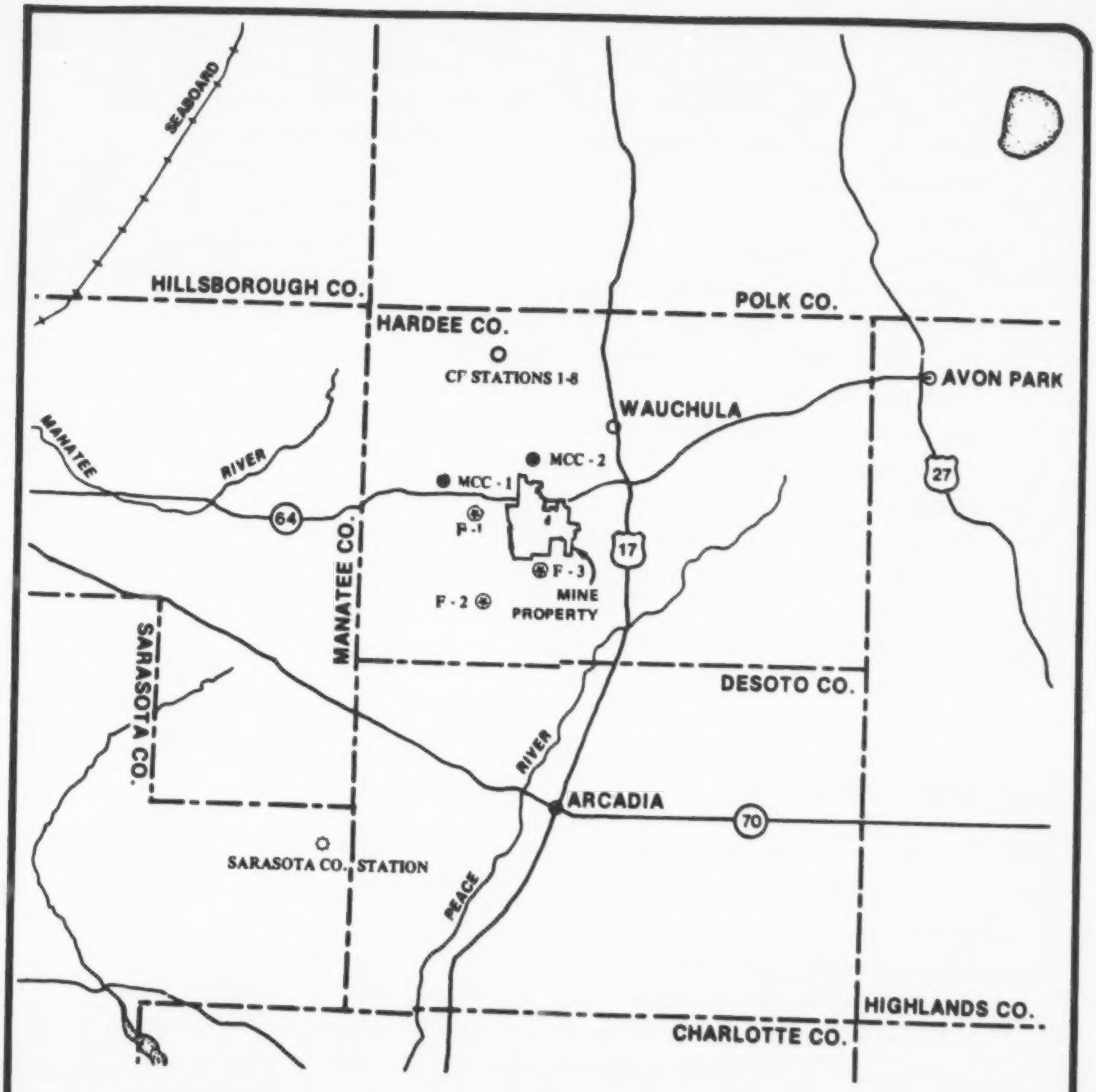

SEABOARD
HILLSBOROUGH CO.
POLK CO.
HARDEE CO.
CF STATIONS 1-8
AVON PARK
WAUCHULA
MANATEE
RIVER
MCC - 2
MCC - 1
64
27
F - 1
17
F - 3
MINE
PROPERTY
F - 2
SARASOTA CO.
MANATEE CO.
DESOTO CO.
RIVER
ARCADIA
70
SARASOTA CO. STATION
PEACE
HIGHLANDS CO.
CHARLOTTE CO.

FIGURE 3-6. LOCATIONS OF AMBIENT MONITORING STATIONS IN THE VICINITY OF THE FARMLAND PROPOSED MINE PROPERTY.

⊛ FARMLAND INDUSTRIES STATIONS
○ CF INDUSTRIES STATIONS
● MISSISSIPPI CHEMICAL CORPORATION STATIONS
○ SARASOTA COUNTY STATION
N
0
5
10
20
KILOMETERS

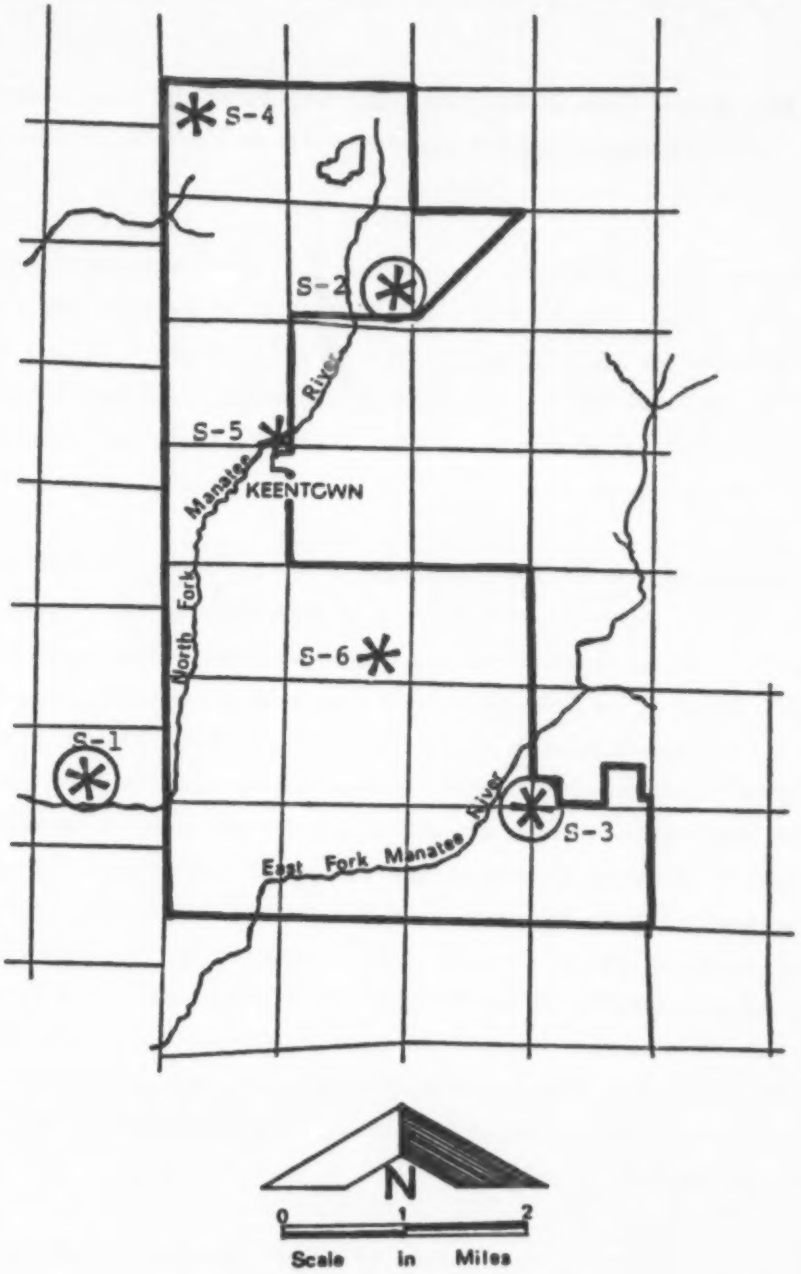
SOURCE: FARMLAND INDUSTRIES, INC., DRI, JUNE 1979

of the data plots reveals that averages are probably less than 5 ppb (13 $\mu g/m^3$). All stations recorded similar maximum 24-hr values of about 30 $\mu g/m^3$.

Maximum 24-hr values at the eight-station CF network are shown in Table 3-19. These stations are located about 20 km from the Polk County phosphate district and the many sulfuric acid plants existing in that area. The Farmland site is located approximately another 20 km south of the CF site, and lower ambient sulfur dioxide levels are expected to exist at the Farmland site.

Measurements of SO_2 were made at three locations in the general vicinity of the proposed Estech site in Manatee County (Figure 3-7). As indicated in Table 3-18, a maximum 24-hr average concentration of 164.4 $\mu g/m^3$ was observed at Station 1 on a day when concentrations at other nearby sites ranged from 0 to 22 $\mu g/m^3$. The Estech report indicates the measurement is suspect and likely the product of an unidentified error. The next highest 24-hr average at Station 1 was 51.4, a value more consistent with measurements at the other two locations. The Duette Mine maximum 24-hr average concentrations at three monitoring sites were reported as 51.4, 50.9, and 49.1 $\mu g/m^3$, respectively. This compares with maximum values of 28 to 32 $\mu g/m^3$ obtained at CF. The higher values at the Estech site may possibly be attributed to the closer proximity of the site to the FP&L Manatee electric utility plant. However, the measured maximum values still remain well below the state and Federal ambient air quality standards.

From January 1979 to December 1979 ESE operated a Meloy 185 continuous SO_2 analyzer near Farmland's proposed mine site. Table 3-20 is a summary of data measured. The annual arithmetic mean standard for SO_2 is 60 $\mu g/m^3$. The measured arithmetic mean at the Farmland site was 4 $\mu g/m^3$ for the time period January 1979 through October 1979. The maximum 3-hr SO_2 concentration was 157 $\mu g/m^3$, which is 12 percent of the


S-4
S-2
River
S-5
Manatee
KEENTOWN
North Fork
S-6
S-1
S-3
River
East Fork Manatee
N
0
1
2
Scale in Miles

⊛ **PRIMARY SITE** TSP_1, SO_2, F^-_{atm}, F^-_{veg}

✱ **SECONDARY SITE** F^-_{veg}

FIGURE 3-7. ESTECH GENERAL CHEMICAL COMPANY AIR QUALITY SAMPLING LOCATIONS.

SOURCE: U.S. ENVIRONMENTAL PROTECTION AGENCY (1979b)

1300 μg/m^3 standard. The maximum 24-hr SO_2 concentration was 69 μg/m^3, or 26 percent of the 260 μg/m^3 standard.

EPA (1978) indicated that SO_2 standards are likely to be exceeded in Polk and Hillsborough Counties, while the levels in the other counties are quite low, tending to be associated with small localized or transient sources.

County-wide annual averages for the six area counties reporting 24-hr SO_2 data are summarized in Table 3-21. Hillsborough and Polk Counties have the highest averages, but with apparent declines since 1974. DeSoto, Manatee, and Sarasota Counties average less than 12 micrograms per cubic meter. Considering that the 24-hr sampling method has a sensitivity limit of 25 μg/m^3 without special calibration of the sampling apparatus, variations in these low levels are not significant.

Although Hardee County is not in this listing, one may conclude that the anticipated 24-hr annual average is well below the value shown for Hillsborough County and on a par with Manatee, DeSoto, and Sarasota Counties (i.e., 1 to 2 μg/m^3).

Total Suspended Particulates

A summary of available TSP data from the Sarasota County, MCC, and CF monitoring programs is provided in Table 3-22. The arithmetic and geometric mean averages from the two MCC stations (20-40 μg/m^3) are typical of rural, background TSP levels (i.e., no major point sources in the area). No elevated short-term TSP values were recorded at either station. The Sarasota County station also recorded typical rural, background TSP values during the period September 1976 through September 1978.

The eight-station CF network recorded geometric mean values of 28 μg/m^3 or less for the period July 1977 through September 1978. Samples were taken once every 6 days. The short-term TSP standard of 150 μg/m^3

was exceeded on one occasion only (Station AQ-8, August 20, 1978 - 207 μg/m^3). None of the other seven stations recorded high values on this date; therefore this measurement is attributed to a very localized influence.

Measurements of suspended particulates were also conducted at three locations in the general vicinity of the proposed Estech site, as displayed in Figure 3-7. All measurements were performed using high volume samplers. Measurements were conducted on a 6-day interval corresponding to schedules observed by state and Federal regulatory agencies. Summary statistics for 1 year of concurrent measurements at the three monitoring locations are compared with applicable air quality standards in Table 3-23. The maximum 24-hr observation (122 μg/m^3) and a maximum second highest observation (110.4 μg/m^3) occurred at Station 3. The second value compares with Federal primary and state 24-hr ambient air quality standards of 260 and 150 μg/m^3, respectively. The highest annual geometric mean among the three stations was 29.2 μg/m^3. The Federal primary and state annual standards are 75 and 60 μg/m^3, respectively. Data for the year of record at Estech site again suggest relatively low background concentrations. The arithmetic average of the annual geometric means computed for the three monitoring stations was 25 μg/m^3. It is noted that this value is very close to the average value of the eight CF monitoring stations, and is below generally assumed background levels for remote location.

ESE collected TSP samples from three stations in the vicinity of the Farmland mine site from January 1979 to January 1980. These data are summarized in Table 3-24. The observed 24-hr maximum was 74 μg/m^3. The maximum geometric mean was 28 μg/m^3.

County TSP data summaries for the period 1972 to mid-1976 are presented by EPA (1978). These data indicate that the reports of levels exceeding state and Federal standards occurred in Hillsborough, Manatee, Polk, and Sarasota Counties. The number of times the state annual and 24-hr TSP standards were exceeded was considerably higher than observed for SO_2 data, partly because dust can be generated by a variety of sources, and an individual sampling station can be dominated by a very local source such as a parking lot (unpaved), a street (paved or unpaved), or a construction site.

EPA (1978) indicated that the TSP data recorded by CF appeared to be characteristic of relatively undeveloped areas. EPA states that:

> "Only one data point recorded during the September 1975-June 1976 period exceeded the state 24-hour standard. This was attributed to the movement of heavy equipment in the area of the sampling station (Dames and Moore 1977, Urone and Chadbourne 1977). Table 2.11 [3-25] summarizes all of the data showing TSP over 90 $\mu g/m^3$ (24-hour). Only 16 data points fell into this category. Table 2.11 [3-25] also shows the wind direction during the sampling periods that exceeded 90 $\mu g/m^3$. These data do not indicate that there was a strong dependence on north-to-south flow. This would tend to indicate that dust in the area was of more local origin than the SO_2 which caused high recorded values during the same time period. The dates of the high TSP recordings did not correspond well with those of the SO_2 maxima, also confirming the local nature of the dust sources."

Fluorides

Gaseous Fluoride. Ambient gaseous fluoride data from the Sarasota County and CF monitoring stations are presented in Table 3-26. Arithmetic means at all stations were 1 $\mu g/m^3$ or less, and maximum 24-hr concentrations were less than 25 $\mu g/m^3$.

Gaseous fluoride data were also collected at the Farmland site by ESE using a fluoride bubbler sampler (Table 3-27). Only two of the 135 samples analyzed exceeded the minimum detectable limit (MDL) of the sampling procedure, which ranged from 1.4 to 2.8 $\mu g/m^3$. Most concentrations presented in Table 3-27 were derived statistically by ESE and are not measured concentrations. To provide a statistical summary a concentration equal to one-half the MDL was used by ESE in their calculations. The concentrations presented are not judged to be a reliable measure of actual gaseous fluoride concentrations at the site. All that can be stated is that all the values were less than 2.8 $\mu g/m^3$, and that all but two of the values were less than 1.4 $\mu g/m^3$. These may have also been due to sample contamination.

Particulate Fluoride. Particulate fluoride was measured at the Farmland site by ESE using high volume sample filters (Table 3-28). The MDL of this sampling equipment was 0.01 $\mu g/m^3$. The maximum observed value was 0.40 $\mu g/m^3$. The second highest observed value was 0.37 $\mu g/m^3$. The arithmetic means at stations ranged from 0.03 $\mu g/m^3$ to 0.05 $\mu g/m^3$.

Total Fluoride. Measurements of total atmospheric fluoride (Table 3-29) were made at the proposed Estech site at three monitoring locations (Figure 3-7). The following discussion of these results is taken from EPA (1979b):

> "The maximum 24-hour average concentration, 4.9 ppb, was observed at Station 1 in February, 1978. The other maxima were observed in January, 1978. The Florida Department of Environmental Regulation proposed a fluoride regulation in 1976 (.........) which, if adopted, would have imposed ambient standards for daily, monthly, and annual averaging times. The proposed standards are provided only for comparison purposes.
>
> All of the measured averages were below the proposed standards with the exception of one 30-day average at Station 1. An agricultural application of fertilizer in the vicinity of this location may explain what otherwise appears as an anomalous occurrence."

Nitrogen Dioxide

No measurements of NO_2 are available for the immediate vicinity of the proposed Farmland site. Significant NO_2 emissions are generally confined to large sources such as electric power generating stations; thus, one may anticipate that the ambient level of NO_2 in the project site is low. Measurements conducted for the Manatee Electric Power

Generation Station (ESE 1975; 1976; 1977b; 1978) at a site approximately half the distance between the power station and proposed Estech mine development (6 miles) and about 17 miles from the Farmland site suggest that area nitrogen dioxide concentrations are relatively low, with little change over the 4 year period from 1974 to 1978. Yearly annual average concentrations measured at this site ranged from 8 to 10 $\mu g/m^3$, compared with a Federal and state annual standard of 100 $\mu g/m^3$.

BASELINE AIR QUALITY ESTIMATES FROM MODELING

Presently permitted SO_2 and TSP sources located in Hardee County were modeled by ESE (for Farmland) using the EPA CRSTER Single Source Model to determine the expected contributions from these sources to background air quality at the Farmland site. Only three significant sources of emissions are presently in operation or permitted for construction in Hardee County. These are Wauchula Power, American Orange, and Mancini Packing. Wauchula Power and American Orange are located in Wauchula, while Mancini Packing is in Zolfo Springs. Utilizing data received from the FDER, the CRSTER model was executed for these sources for appropriate downwind distances which would encompass the Farmland property. Table 3-30 shows emission rates for these sources based upon permit information and data received from American Orange. This analysis indicates that annual highest and second highest 24-hr particulate matter concentrations due to nearby point sources are very small (less than 3 $\mu g/m^3$). Highest and second highest 24-hr and 3-hr sulfur dioxide concentrations are predicted to be somewhat higher, but well below applicable AAQS (highest and second highest 3-hr concentrations are estimated to be less than 60 $\mu g/m^3$ on the Farmland property). Concentrations would be significantly less the majority of the year. These results from this modeling are consistent with monitoring data summarized in the previous sections.

3.1.3 NOISE

The primary measure for describing environmental baseline noise is the day-night average sound level, abbreviated as DNL, and symbolized as L_{dn}. The DNL is a 24-hr average sound level in which nighttime noise levels occurring between 2200 and 0700 are increased by 10 decibels (dB) before calculation of the 24-hr average. In order to describe the effects of environmental noise in a simple, uniform, and appropriate way, the best descriptors are the long-term equivalent A-weighted sound level (L_{eq}) and a variation with a nighttime weighting, the day-night sound level (L_{dn}). Long-term impact is evaluated by the yearly day-night average sound level, symbolized as L_{dny} and abbreviated as YDNL (EPA 1971; 1974).

The L_{dn} is the primary measure of a noise environment affecting a community over an entire 24-hr day. Typical L_{dn} values for various residential neighborhoods with no defined noise sources other than usual transportation are as follows:

Description	Population Density (People/Square Mile)	L_{dn} (in Decibels)
Rural (undeveloped)	20	35
Rural (partially developed)	60	40
Quiet suburban	200	45
Normal suburban	600	50
Urban	2,000	55
Noisy urban	6,000	60
Very noisy urban	20,000	65

In some instances, it is desirable to estimate the effect of a noise environment on an activity by a shorter measurement duration. In this instance it is useful to consider the average sound level over the period of interest. The average sound level over a specified period of time is symbolized as $L_{eq(T)}$, where T is the time interval of interest. Simplified abbreviations for the 24-hr average and 18-minute average sound levels are L_{24h} and L_{18m}, respectively.

Measurements

An ambient noise measurement program was conducted in the vicinity of the Farmland site to establish the existing noise levels. Baseline noise levels were monitored and recorded at a number of representative locations on the Farmland site area over 2-day periods in September 1979 and January 1980. Measurements were made during the daytime and nighttime periods to determine if variations due to human activities occurred. These noise levels were measured in the A-weighted sound level (L_A), which is designed to electronically simulate the response of the human auditory system. The unit for measurement was the decibel (dB). The measurements were made in accordance with American National Standards Institute, ANSI-SI.13-1971, "Methods for Measurement of Sound Pressure Levels". Instrumentation consisted of General Radio type 1933 precision sound level meters and analyzers. The systems were calibrated before each set of measurements with General Radio 1562 calibrators. The data were recorded in analog form on battery operated Simpson model 2745 recorders.

A six-station monitoring network (Figure 3-8) was established in the vicinity of the Farmland site area to provide representative ambient sound levels generated by all existing local activities (e.g., traffic, farming, etc.). The stations utilized are described as follows:

Monitoring Station 1

This station was located approximately 100 m (328-feet) northeast of the main base air quality/meteorological station in the northeast portion of Section 20. Air quality monitoring and some farming activities were documented.

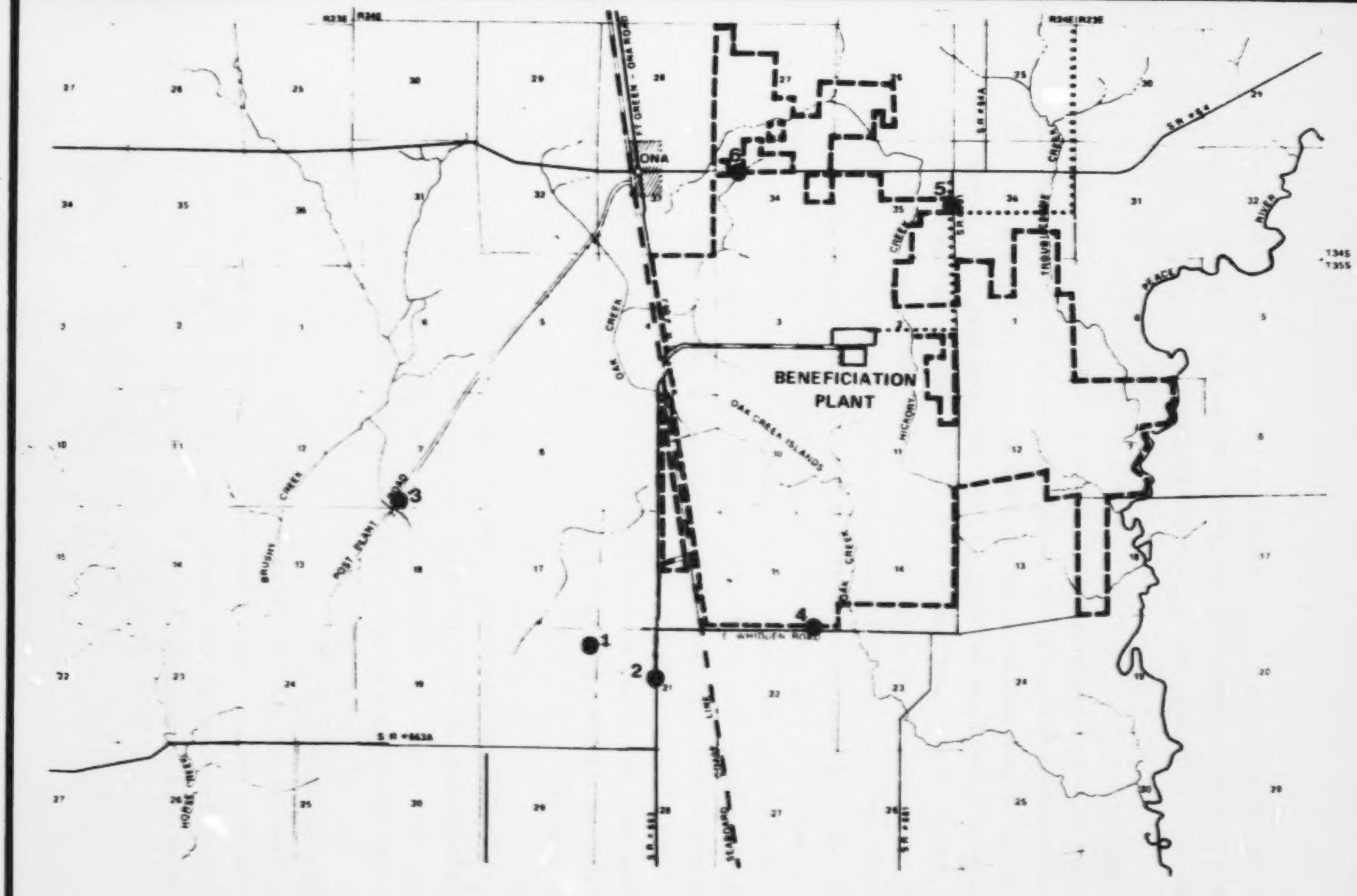

R23E R24E
R24E R23E
T34S
T35S
ONA
FT GREEN - ONA ROAD
S.R. #64
PEACE RIVER
TROUBLESOME CREEK
HICKORY CREEK
BENEFICIATION PLANT
OAK CREEK
OAK CREEA ISLANDS
BRUSHY CREEK
POST PLANT ROAD
HORSE CREEK
S.R. #663A
S.R. #663
S.R. #661
SEABOARD COAST LINE
E. WHIDLEN ROAD
1
2
3
4
5
6
N
0 2,000 4,000
SCALE IN FEET

FIGURE 3-8. LOCATIONS OF NOISE MONITORING STATIONS IN THE VICINITY OF THE FARMLAND INDUSTRIES, INC. PROPERTIES - FALL 1979 AND WINTER 1980.

Monitoring Station 2

This station was located along Route 663 in Section 21, approximately 305 m (1000-feet) from a farm residence and about 6 m (20-feet) west of State Highway 663.

Monitoring Station 3

This station was located in the north-northwest portion of Section 18 along Post Plant Road.

Monitoring Station 4

This station was located on East Whidden Road in Section 15.

Monitoring Station 5

This station was located approximately 100 m (328-feet) from residences and about 15 m (50-feet) from Route 661, which forms the boundary between Sections 35 and 36. This station is near the extreme eastern boundary line of the property. Many of the residence and road traffic activities were documented.

Monitoring Station 6

This station was located 100 m (328-feet) from residences (a home and a house trailer) and about 8 m (25-feet) south of Highway 64, which is near the major property to the North. Traffic on Highway 64 was documented along with activities at the residences.

Ambient noise levels were recorded at six locations in the Farmland site area. At each of the six locations, 4 L_{eq} (18 minute) measurements were made and recorded during the fall and winter (1980) season. These direct measurement values were used to determine estimated DNL sound level values for the area. These DNL values are considered conservative--the estimated nighttime L_{eq} values for the determination of the DNL values are based on the measured daytime and nighttime L_{eq} values, which represent 15 hours and 9 hours, respectively. Daytime sound levels are normally higher than baseline nighttime sound levels.

At each of the monitoring stations noise sources and their maximum sound levels were identified. This information was documented on the analog strip charts along with the continuous record of the sound levels. The recorded sound levels were tabulated and logarithmically averaged (Tables 3-31 and 3-32) to reveal general patterns in diurnal variations of the ambient noise levels, as well as deviation from these general patterns that may be a result of intermittent man-made or natural noises. The sound levels are reported in terms of a statistical-time-distribution. This analysis takes into account the constant variations in amplitude of the sound pressure level over both short-term and long-term intervals. Tables 3-31 and 3-32 present the sound levels in the Farmland site area at different times of the day at each monitoring station during the fall and winter survey periods, respectively. Sound levels are normally more variable during the daytime and more constant at nighttime. The magnitude of the levels is distorted by the high levels measured at Stations 2 and 6 and the logarithmic averaging process. The highest L_{eq} and L_{dn} values (at Station 6 in the fall period) were due to the traffic on Highway 64 and activities at nearby residences. The relatively high values recorded at Station 2 during the survey were also due to the traffic on Highway 663 and nearby farming activities. The high nighttime L_{eq} (L_n) at Station 3 was due to calls of frogs and toads following heavy rains and thundershowers which had passed over the area. The average L_{dn} for each of the six stations was as follows: Station 1, 49.7; Station 2, 66.9; Station 3, 52.0; Station 4, 53.5; Station 5, 61.6; and Station 6, 67.0.

3.2 ENVIRONMENTAL CONSEQUENCES OF THE ALTERNATIVES

The proposed mining and processing of phosphate rock at the Farmland site and subsequent reclamation of disturbed land will result in adverse impacts on the existing air environment. These impacts will be relatively minor, arising primarily from materials handling and distribution equipment. EPA (1978) reports that the ground moisture content in most operations is sufficient to prevent even these emissions.

A detailed description of the air quality, meteorology, and noise impacts associated with the alternative methods of accomplishing the identified project goals is presented in this section. The discussion is arranged by project component so that the alternative methods for any given component can be examined to an equal degree, thus providing a basis for comparison of alternatives. The first alternative discussed under each project component is Farmland's proposed action.

Only those project components having impacts relating to air quality, meteorology, and noise are considered in this section. The last discussion within the section considers the air quality, meteorology, and noise impacts of the no action alternative as it applies to the project as a whole.

3.2.1 MINING

Dragline Mining (Farmland's Proposed Action)

The dragline used in the proposed mining operation would be electrically powered and thus would not increase combustion emission levels. Some increase in ambient TSP levels may occur as a result of the handling of overburden and matrix by mining equipment. This should be minimal because of the wet nature of these materials.

Fugitive dust emissions in the mining area will be minimized by maintaining a vegetative cover on all reserve land until mining is imminent. In the interim between land clearing and mining, some land will be exposed and subject to activity that may generate fugitive dust emissions. Between 50-200 acres will likely be in this category at any given time. Fugitive dust emissions generated from such areas should be comparable to dust emissions from grove cultivation and other existing agricultural operations. If open burning is conducted, particulate matter, nitrogen oxides, sulfur dioxide, carbon monoxide, and hydrocarbons will be emitted. However, because the vegetation on the portions of the site which are to be cleared is relatively sparse very little burning will be required.

Increased noise levels will occur in the site area as a result of site preparation and mining activities. EPA (1979) presents noise data from actual measurements of a dragline mining operation. These data indicate that a sound pressure level (SPL) of 56-62 dB(A) can be expected at about 200-feet from the dragline itself. Pitt (1980) reports that land clearing in preparation for mining would produce somewhat higher noise levels (L_{dn}), between 65-70 dB(A) at this same distance.

In order to assess the impact of such noise levels on sensitive receptors in the area, the contribution of mining noises to the total composite noise level which would be experienced at the Town of Ona was examined. Current L_{dn} values experienced at Ona are on the order of 60 dB(A). While the noise levels due to land clearing and mining will change as different areas are mined, an analysis of the impact for a given year (year 7) indicates that no increase over existing levels would occur. Mining activities will be closest to Ona during years 16 and 19. L_{dn} noise levels at nearby residences will likely be higher than current levels (e.g., land clearing activities at 150 feet would produce L_{dn} noise levels on the order of 70 dB[A]). Mining noise levels at this same distance would be on the order of 60 dB(A). The Hardee County Mining Ordinance does not allow mining within 500 feet of a residence, thus the actual noise levels which would be experienced at the nearest residence would be less than these values.

Bucketwheel Mining

As in the case of draglines, bucketwheel excavators would typically be electrically powered; thus, air emissions would not be increased. There would likely be more handling of overburden on conveyor systems, etc.; so that TSP emissions might be greater than for draglines. Fugitive emissions from cleared areas and emissions from open burning would be similar to those for dragline mining.

Because of the additional handling equipment needed, noise levels from bucketwheels would probably be greater than would be experienced using draglines.

Dredge Mining

It is assumed the dredges would also be electrically powered; however they would likely produce lower TSP levels than either draglines or bucketwheels because of the slurry handling of overburden and matrix. Fugitive emissions from cleared areas and emissions from open burning would be similar to those for dragline mining.

Noise levels would probably be similar to those expected for dragline mining.

3.2.2 MATRIX TRANSPORT

Slurry Transport (Farmland's Proposed Action)

Matrix would be transported in a water slurry from the active mine pit to the beneficiation plant. No significant emissions should result.

Data presented by EPA (1979) indicate that the noise levels associated with matrix pumping are minor when considered in combination with the nearby dragline. A peak SPL of 62 dB(A) was recorded for a dragline alone, as compared to a peak of 68* dB(A) for dragline and slurry pit pump together.

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*Included outside noises as well.

Conveyor Transport

Matrix would be placed on a belt conveyor for transport from the active mine pit to the beneficiation plant. TSP levels near the conveyor would likely be higher than if slurry pumping were used.

Noise levels associated with conveyor transport would be greater than for slurry pumping. Pitt (1980) indicates that L_{dn} levels on the order of 70 dB(A) could occur at a distance of 125 feet from such an operating conveyor. Levels on the order of 60 dB(A) would occur at 1250 feet. This noise would also occur along the total length of the conveyor.

Truck Transport

Matrix would be transported over haul roads to the beneficiation plant in large off road trucks. This would result in higher TSP as well as combustion emissions than either of the other matrix transport alternatives.

Noise levels associated with truck transport would also be substantially higher than for slurry pumping. The noise produced would be more intermittent than for conveyor transport, but could be of a higher level when it occurs (i.e., when a truck would pass by).

3.2.3 MATRIX PROCESSING

Conventional Matrix Processing (Farmland's Proposed Action)

Conventional matrix processing methods utilize flotation reagents in order to separate waste materials from the phosphate rock. Since some of these reagents are volatile (e.g., kerosene), local increases in their atmospheric levels are expected.

Noise levels associated with a conventional matrix processing plant are presented by EPA (1979). At a distance of 225 feet, the average SPL was determined to be 72 dB(A). The anticipated L_{dn} value for the operating plant is expected to be on the order of 600 dB(A) at a distance of

900 feet (Pitt 1980). This will result in a contribution of about 40 dB(A) to the composite L_{dn} noise level at the Town of Ona.

Dry Matrix Processing

Dry processing would require that matrix be dried, crushed, and sized (by air separation and/or electrostatic separation). This would require the burning of fuel (for drying) and result in elevated air pollutant levels in the area.

Noise levels associated with a dry matrix processing plant are expected to be somewhat greater than discussed above for conventional (wet) processing.

3.2.4 RECLAMATION

Farmland's Proposed Reclamation Plan

Farmland proposes to reclaim much of the sand-clay mix disposal areas on the mine site as agricultural land. This will require that the windrows of overburden created during the mining operation be leveled using heavy equipment. The operation of this equipment will result in local increases in combustion emission levels.

The operation of heavy equipment during leveling, etc. would result in increased noise levels in the area. Data presented by EPA (1979) indicate that such SPLs could be on the order of 36-93 dB(A) within the area being reclaimed (i.e., at distances of 30-200 feet). The maximum values measured were at close proximity (30 feet) to an operating payscraper. Noise levels would be mostly on the order of 75 dB(A) at a distance of 200 feet.

Conventional Reclamation

Conventional reclamation is the type of reclamation which has been practiced in the Florida phosphate industry over the past years. Major features of this type of reclamation are the creation of extensive areas of improved pasture on reclaimed clay settling areas and numerous land and lake areas.

Because of the nearly flat topography which results from the settling of clay with the separate disposal areas little grading of such areas would be necessary to produce a surface suitable for use as pasture. Therefore, emissions and noise levels from equipment would likely be less than for reclamation of sand-clay mix areas. The net difference would be dependent upon the amount of ditching, etc. which would be required in order to dry the upper layer of separate clay disposal areas to the point where seeding could be accomplished.

Natural Mine Cut Reclamation

Natural mine cut reclamation would eliminate the need for overburden leveling, etc., and thus result in a decrease in the amount of combustion emissions from heavy equipment. The noise levels associated with the operation of this equipment would also be less than for Farmland's proposed reclamation plan and conventional reclamation.

3.2.5 THE NO ACTION ALTERNATIVE

Under the no action alternative the meteorologic and noise characteristics of the site would likely remain as described in Section 3.1. Future air quality changes may occur, however, because of new sources which may be permitted in the region in years to come or changes in fuels used at existing sources.

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Table 3-1. MONTHLY AND ANNUAL MEAN TEMPERATURES (°F) FOR REPRESENTATIVE LOCATIONS SURROUNDING THE FARMLAND SITE

	Location					
Month	Arcadia	Bartow	Bradenton	Lakeland	Tampa	Wauchula
January	62.1	61.3	61.3	60.8	60.4	61.8
February	63.5	63.0	62.5	62.1	61.8	63.1
March	67.6	67.3	66.3	66.3	66.0	67.1
April	72.2	72.7	71.3	72.0	72.0	72.1
May	76.7	77.4	76.1	77.0	77.2	76.6
June	80.0	81.0	79.9	80.5	81.0	80.2
July	81.2	82.1	81.2	81.6	81.9	81.3
August	81.7	82.4	81.4	81.9	82.2	81.6
September	80.3	80.8	80.4	80.2	80.8	80.2
October	74.7	74.9	74.7	74.3	74.7	74.7
November	67.6	67.2	67.4	66.8	66.8	67.4
December	63.0	62.4	62.6	62.0	61.6	62.7
ANNUAL	72.6	72.7	72.1	72.1	72.2	72.4

Source: U.S. Department of Commerce (1973).

Table 3-2. AVERAGE AND EXTREME TEMPERATURES AT WAUCHULA, FLORIDA (IN °F)

Month	Average	Extreme Maximum	Extreme Minimum
Jan	61.8	90	22
Feb	63.1	91	24
Mar	67.1	93	29
Apr	72.1	99	34
May	76.6	104	40
Jun	80.2	103	55
Jul	81.3	102	59
Aug	81.6	99	61
Sep	80.2	97	55
Oct	74.7	95	38
Nov	67.4	90	24
Dec	62.7	89	22
Annual	72.4	104	22

Source: Adley Associates, Inc. (1979).

Table 3-3. AVERAGE AND EXTREME TEMPERATURES (°F) AT TAMPA, FLORIDA[a]

	NORMAL			EXTREMES[b]			
Month	Daily Maximum	Daily Minimum	Monthly Means	Record Highest	Year	Record Lowest	Year
January	71.3	51.0	61.2	81	1970+	24	1970+
February	72.8	52.6	62.7	84	1965	27	1967+
March	76.0	56.0	66.0	87	1965+	35	1968
April	81.4	61.3	71.4	92	1970+	45	1966+
May	87.0	66.6	76.8	96	1967	50	1969
June	89.7	71.7	80.6	97	1964	61	1965
July	89.4	73.4	81.6	97	1964	63	1970
August	90.3	73.7	82.0	97	1970	68	1969
September	88.7	72.3	80.5	95	1966	64	1967
October	83.8	65.6	74.7	93	1966	40	1964
November	76.8	56.8	66.8	86	1964	23	1970
December	72.5	52.1	62.3	82	1967	27	1968
YEAR	81.6	62.8	72.2	97	August 1970+	23	November 1970

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[a] Means and extremes above are from existing and comparable exposures. Annual extremes have been exceeded at other sites in the locality as follows: highest temperature 98 in June 1952+; lowest temperature 18 in December 1962; maximum monthly snowfall 0.1 in Feburary 1889; fastest mile wind 84 in September 1935.

[b] For period November 1963 through the current year.

Source: U.S. Department of Commerce Local Climatological Data for Tampa, Florida.

Table 3-4. AVERAGE AND EXTREME TEMPERATURES (°F) AT LAKELAND, FLORIDA

	NORMAL[a]			EXTREMES			
Month	Daily Maximum	Daily Minimum	Monthly Means	Record Highest	Year	Record Lowest	Year
January	70.5	51.0	60.8	85	1947	25	1970
February	72.0	52.2	62.1	88	1962	28	1970
March	76.2	56.3	66.3	91	1949	30	1943
April	81.8	62.1	72.0	95	1968	40	1950
May	86.8	67.1	77.0	99	1945	54	1971
June	89.7	71.3	80.5	100	1945	63	1949
July	90.4	72.7	81.6	101	1942	66	1947
August	90.4	73.3	81.9	98	1961	63	1947
September	88.0	72.3	80.2	97	1944	61	1947
October	82.4	66.1	74.3	94	1959	43	1957
November	76.0	57.5	66.8	89	1946	28	1970
December	71.5	52.5	62.0	85	1971	20	1962
YEAR	81.3	62.9	72.1	101	July 1942	20	December 1962

[a] Normals for the period 1940-1970.

Source: U.S. Department of Commerce Local Climatological Data for Lakeland, Florida.

Table 3-5. MONTHLY AND ANNUAL PRECIPITATION NORMALS FOR REPRESENTATIVE LOCATIONS SURROUNDING THE FARMLAND SITE

	Locations					
Month	Arcadia	Avon Park	Bartow	Lakeland	Tampa	Wauchula
January	2.16	2.02	2.31	2.32	2.33	2.20
February	2.55	2.56	2.98	2.52	2.86	2.79
March	2.95	3.07	3.75	4.02	3.89	3.38
April	2.51	2.84	2.96	2.57	2.10	2.85
May	4.10	3.80	4.58	3.44	2.41	3.99
June	9.07	8.75	7.77	6.70	6.49	8.66
July	8.84	7.60	8.74	8.09	8.43	9.04
August	7.79	7.24	8.03	7.18	8.00	7.48
September	7.57	7.20	6.94	6.06	6.35	7.88
October	4.07	4.32	3.16	2.84	2.54	3.05
November	1.84	1.63	1.96	1.60	1.79	1.65
December	1.98	1.56	2.08	2.09	2.19	1.70
ANNUAL	55.43	52.59	55.26	49.43	49.38	54.66

Source: U.S. Department of Commerce (1973).

Table 3-6. **MONTHLY AND ANNUAL MEAN AND EXTREME RAINFALL AT WAUCHULA, FLORIDA (IN INCHES)**

Month	Mean	Maximum	Minimum
Jan	2.20	7.20	0.08
Feb	2.80	8.92	0.19
Mar	3.39	9.22	0.08
Apr	2.85	8.26	0.00
May	3.99	11.32	0.01
Jun	8.66	18.40	2.40
Jul	9.03	15.54	2.80
Aug	7.48	15.53	2.97
Sep	7.88	18.06	1.19
Oct	3.05	9.67	0.00
Nov	1.63	6.43	0.02
Dec	1.74	4.77	0.11

Period of Record: Average = 1941-1970
Extremes = 1933-1970

Annual Rainfall Summary:

Mean - 55.02 in. (based on the 28 years between 1941 and 1970 with complete records)
Maximum - 83.48 in. (in 1953)
Minimum - 36.93 in. (in 1961)

Source: Adley Associates, Inc. (1979).

Table 3-7. MONTHLY AND ANNUAL MEAN AND EXTREME RAINFALL AT TAMPA FLORIDA

Month	Normal Total	Maximum Monthly	Year	Minimum Monthly	Year	Maximum in 24 hrs.	Year
January	2.13	8.02	1948	T	1950	3.29	1953
February	2.84	7.95	1963	0.21	1950	3.25	1963
March	3.75	12.64	1959	0.06	1956	5.20	1960
April	2.84	6.59	1957	T	1967	3.70	1951
May	2.85	7.55	1959	0.47	1953	3.45	1959
June	7.28	11.11	1957	1.86	1951	4.31	1957
July	8.62	20.59	1960	2.31	1962	12.11	1960
August	8.24	18.59	1949	2.35	1952	5.37	1949
September	6.89	13.04	1947	2.20	1967	4.67	1950
October	2.78	7.36	1952	0.25	1961	2.54	1968
November	1.46	6.12	1963	T	1960	4.22	1963
December	1.89	6.66	1950	0.21	1956	3.28	1969
ANNUAL	51.57	20.59	July 1960	T	April 1967	12.11	July 1960

Normals for period 1940-1970

Source: U.S. Department of Commerce Local Climatological Data for Tampa, Florida.

Table 3-8. MONTHLY AND ANNUAL MEAN AND EXTREME RAINFALL AT LAKELAND FLORIDA

Month	Normal	Maximum Monthly	Year	Minimum Monthly	Year	Maximum in 24 hrs.	Year
January	2.32	8.74	1948	0.12	1950	3.88	1945
February	2.52	6.59	1963	0.17	1945	3.92	1971
March	4.02	12.94	1960	0.78	1949	6.96	1960
April	2.57	8.48	1959	0.00	1967	4.41	1941
May	3.44	9.68	1957	0.13	1953	4.36	1968
June	6.70	14.86	1968	1.87	1948	10.12	1945
July	8.09	15.67	1960	3.09	1961	6.66	1960
August	7.18	15.57	1948	3.40	1942	6.20	1949
September	6.06	11.68	1947	0.81	1972	6.34	1960
October	2.84	6.72	1952	0.04	1974	4.99	1944
November	1.60	5.94	1941	T	1960	3.97	1963
December	2.09	5.33	1941	0.09	1944	4.88	1949
ANNUAL	49.43	15.67	July 1960	0.00	April 1967	10.12	June 1945

Source: U.S. Department of Commerce Local Climatological Data for Lakeland, Florida.

Table 3-9. RECORDED HUMIDITY AND INCIDENCE OF HEAVY FOG

	Tampa			Lakeland			Ft. Myers		
	Relative Humidity			Relative Humidity			Relative Humidity		
Month	High	Low	Days of Fog	High	Low	Days of Fog	High	Low	Days of Fog
January	86	59	6	-	-	4	88	59	5
February	85	56	3	-	-	3	88	57	3
March	86	55	3	-	-	2	87	53	3
April	88	51	2	-	-	1	89	49	2
May	85	49	1	-	-	-	86	49	1
June	86	59	-	-	-	-	88	60	-
July	87	63	-	-	-	-	87	60	-
August	90	65	-	-	-	-	88	61	-
September	89	60	-	-	-	-	90	63	-
October	88	58	1	-	-	1	88	59	1
November	88	54	3	-	-	3	88	55	2
December	88	57	5	-	-	5	89	55	4

Source: Bradley (1974).

Table 3-10. OPEN PAN EVAPORATION RATES FOR LAKE ALFRED (1971-1977)

Year	Total Open Pan Evaporation (inches)
1977	Incomplete Yearly Record
1976	Incomplete Yearly Record
1975	69.07
1974	70.08
1973	69.04
1972	69.30
1971	68.72

Source: U.S. EPA (1979a)

Table 3-11. PREVAILING WIND SPEED AND DIRECTION

	Tampa		Lakeland		Ft. Myers	
Month	Speed m/sec (mi/hr)	Dir	Speed m/sec (mi/hr)	Dir	Speed m/sec (mi/hr)	Dir
Jan	4.1 (9.1)	N	3.3 (7.3)	NE	3.8 (8.6)	E
Feb	4.3 (9.7)	E	3.5 (7.8)	NE	4.1 (9.2)	E
Mar	4.5 (10.0)	S	3.5 (7.8)	W	4.3 (9.5)	SW
Apr	4.3 (9.7)	ENE	3.4 (7.7)	E	4.0 (8.9)	E
May	4.1 (9.2)	E	3.1 (6.9)	E	3.7 (8.2)	E
Jun	3.8 (8.4)	E	2.8 (6.2)	E	3.3 (7.4)	E
Jul	3.4 (7.6)	E	2.5 (5.7)	S	3.1 (6.9)	ESE
Aug	3.3 (7.4)	ENE	2.5 (5.5)	NE	3.1 (6.9)	E
Sep	3.8 (8.6)	ENE	3.0 (6.6)	NE	3.5 (7.9)	E
Oct	4.1 (9.1)	NNE	3.2 (7.2)	NE	3.8 (8.5)	NE
Nov	4.0 (8.9)	NNE	3.1 (6.9)	NE	3.7 (8.3)	NE
Dec	4.0 (8.9)	N	3.1 (6.9)	NE	3.7 (8.3)	NE

Source: Bradley (1974).

Table 3-12. SEASONAL WIND DISTRIBUTION FREQUENCY AND WIND SPEED FOR LAKELAND (1942-1945)

Direction	Spring				Summer				Fall				Winter				Annual			
	Distribution Frequency %	Mean Wind Speed			Distribution Frequency %	Mean Wind Speed			Distribution Frequency %	Mean Wind Speed			Distribution Frequency %	Mean Wind Speed			Distribution Frequency %	Mean Wind Speed		
		MPH	Knots	M/Sec		MPH	Knots	M/Sec		MPH	Knots	M/Sec		MPH	Knots	M/Sec		MPH	Knots	M/Sec
N	4.1	5.9	6.8	3.48	3.2	4.6	5.3	2.71	10.2	4.8	5.5	2.82	8.6	5.6	6.5	3.34	6.9	7.1	8.2	4.21
NNE	5.6	6.8	7.8	4.02	2.3	5.2	6.0	3.10	8.5	5.8	6.7	3.44	7.0	6.7	7.7	3.96	6.1	8.3	9.6	4.92
NE	8.4	7.4	8.5	4.40	7.3	4.6	5.3	2.71	10.6	6.5	7.5	3.87	8.5	6.1	7.0	3.60	11.0	8.3	9.6	4.92
ENE	9.6	8.3	9.6	4.96	6.0	5.4	6.2	3.18	9.3	6.5	7.5	3.86	6.8	6.4	7.4	3.81	8.0	9.0	10.4	5.33
E	9.9	6.9	8.0	4.13	6.6	4.5	5.2	2.69	8.6	6.3	7.3	3.76	6.0	5.8	6.7	3.44	7.7	7.3	8.4	4.33
ESE	8.0	7.4	8.5	4.35	6.1	5.2	6.0	3.08	3.1	5.0	5.8	3.00	3.1	6.4	7.4	3.78	4.8	8.1	9.3	4.82
SE	8.9	6.9	8.0	4.10	10.7	4.3	4.9	2.53	4.2	4.4	5.1	2.62	4.4	5.2	6.0	3.08	6.7	7.0	8.1	4.15
SSE	6.3	7.6	8.8	4.54	5.7	4.8	5.5	2.85	1.7	4.4	5.1	2.65	4.3	7.0	8.1	4.16	4.3	8.6	9.9	5.10
S	5.1	7.1	8.2	4.24	6.3	4.5	5.2	2.70	2.8	4.3	4.9	2.53	5.5	6.8	7.8	3.99	4.8	7.9	9.1	4.68
SSW	4.5	8.2	9.5	4.88	6.4	4.9	5.7	2.92	1.8	4.5	5.2	2.70	4.4	8.0	9.2	4.77	4.1	9.0	10.4	5.33
SW	5.5	8.1	9.3	4.80	7.4	5.3	6.1	3.13	2.9	4.6	5.3	2.74	5.3	7.2	8.3	4.26	5.1	8.7	10.0	5.16
WSW	3.2	8.3	9.6	4.95	2.8	5.6	6.4	3.28	1.7	5.3	6.1	3.16	2.9	6.9	8.0	4.10	2.6	9.2	10.6	5.45
W	4.0	7.1	8.2	4.21	4.1	6.1	7.0	3.60	2.7	5.4	6.2	3.20	4.6	6.7	7.7	3.95	3.8	8.5	9.8	5.04
WNW	3.5	7.4	8.5	4.35	3.3	6.3	7.3	3.77	3.1	6.7	7.7	3.96	6.9	7.7	8.9	4.60	4.3	9.6	11.1	5.69
NW	3.9	7.4	8.5	4.36	4.2	5.5	6.3	3.26	6.3	5.4	6.2	3.19	8.2	6.4	7.4	3.80	5.9	8.3	9.6	4.92
NNW	3.0	5.6	6.4	3.29	2.1	5.0	5.8	2.98	5.2	4.5	5.2	2.67	5.9	5.6	6.4	3.29	4.3	7.0	8.1	4.16
CALM	6.4				16.4				9.6				7.3				9.6			
Mean Wind Speed		7.3	8.4	4.32		5.1	5.9	3.04		4.9	5.6	2.88		6.6	7.6	3.91		7.4	8.5	4.39

Source: NOAA (Undated).

Table 3-13. SEASONAL WIND DISTRIBUTION FREQUENCY AND WIND SPEED FOR TAMPA (1965-1969)

Direction	Spring				Summer				Fall				Winter				Annual			
	Distribution Frequency %	Mean Wind Speed			Distribution Frequency %	Mean Wind Speed			Distribution Frequency %	Mean Wind Speed			Distribution Frequency %	Mean Wind Speed			Distribution Frequency %	Mean Wind Speed		
		MPH	Knots	M/Sec		MPH	Knots	M/Sec		MPH	Knots	M/Sec		MPH	Knots	M/Sec		MPH	Knots	M/Sec
N	4.1	5.8	6.7	3.44	3.2	6.3	7.2	3.71	10.2	6.4	7.4	3.81	8.6	6.5	7.5	3.86	6.5	6.3	7.3	3.75
NNE	5.6	6.0	6.9	3.55	2.3	5.1	5.9	3.04	8.5	6.9	7.9	4.07	7.0	6.9	7.9	4.07	6.3	6.5	7.5	3.86
NE	8.4	6.6	7.6	3.91	7.3	5.4	6.2	3.19	10.6	6.9	7.9	4.07	8.5	6.9	7.9	4.07	8.0	6.5	7.5	3.86
ENE	9.6	6.3	7.3	3.75	6.0	5.3	6.1	3.14	9.3	6.5	7.5	3.86	6.8	6.2	7.1	3.71	10.8	6.2	7.1	3.71
E	9.9	7.3	8.4	4.32	6.6	5.4	6.2	3.19	8.6	6.6	7.6	3.91	6.0	6.3	7.2	3.71	14.8	6.3	7.3	3.75
ESE	8.0	7.2	8.3	4.27	6.1	5.6	6.5	3.35	3.1	6.3	7.2	3.71	3.1	6.5	7.5	3.86	6.8	6.3	7.3	3.75
SE	8.9	7.1	8.2	4.22	10.7	5.5	6.3	3.24	4.2	6.6	7.6	3.91	4.4	6.9	7.9	4.07	4.9	6.4	7.4	3.81
SSE	6.3	6.9	8.0	4.12	5.7	5.5	6.3	3.24	1.7	5.6	6.4	3.29	4.3	6.9	7.9	4.07	5.1	6.2	7.1	3.71
S	5.1	8.7	10.0	5.15	6.3	6.3	7.2	3.71	2.8	6.4	7.4	3.81	5.5	7.8	9.0	4.63	5.1	7.4	8.5	4.37
SSW	4.5	8.2	9.4	4.83	6.4	6.8	7.8	4.01	1.8	6.4	7.4	3.81	4.4	7.0	8.1	4.17	3.2	7.3	8.4	4.32
SW	5.5	7.4	8.5	4.37	7.4	6.3	7.3	3.75	2.9	5.9	6.8	3.50	5.3	6.4	7.4	3.81	2.6	6.6	7.6	3.91
WSW	3.2	7.5	8.6	4.43	2.8	6.4	7.4	3.81	1.7	6.2	7.1	3.71	2.9	5.9	6.8	3.50	4.0	6.3	7.6	3.91
W	4.0	8.7	10.0	5.15	4.1	7.0	8.1	4.17	2.7	6.7	7.7	3.96	4.6	6.9	7.9	4.07	8.5	7.6	8.7	4.48
WNW	3.5	7.6	8.8	4.53	3.3	6.3	7.3	3.75	3.1	7.1	8.2	4.22	6.9	8.0	9.2	4.74	3.8	7.4	8.5	4.37
NW	3.9	7.0	8.1	4.17	4.2	6.1	7.0	3.60	6.3	6.7	7.7	3.96	8.2	8.1	9.3	4.78	4.7	7.1	8.2	4.22
NNW	3.0	6.7	7.7	3.96	2.1	5.8	6.7	3.45	5.2	6.5	7.5	3.86	5.9	8.6	9.9	5.10	4.8	7.3	8.4	4.32
CALM	6.4				16.4				9.6				7.3				4.6			
Mean Wind Speed		6.9	8.0	4.12		5.6	6.5	3.35		6.3	7.2	3.71		6.6	7.6	3.91		6.3	7.3	3.75

Source: NOAA (1972).

Table 3-14. SEASONAL RELATIVE FREQUENCY DISTRIBUTION BY PASQUILL STABILITY CLASSES FOR TAMPA, 1965-1969

Stability Class	Season				
	Spring	Summer	Fall	Winter	Annual
A	0.24	0.73	0.19	0.03	0.31
B	6.74	13.13	5.72	2.47	7.04
C	15.25	17.85	13.50	12.36	14.76
D	40.39	28.64	35.50	45.29	37.42
E, F	37.35	39.65	45.09	39.85	40.47
TOTAL	100.00	100.00	100.00	100.00	100.00

Source: NOAA (1972).

Table 3-15. MEAN ANNUAL AND SEASONAL MAXIMUM AND MINIMUM MIXING DEPTHS (M) FORM NON-PRECIPITATION EVENTS, WITH MEAN WIND SPEEDS (M/SEC) THROUGH THE MIXING DEPTH AND VENTILATION FACTORS (M^2/SEC) FOR TAMPA FOR THE PERIOD 1960-1964

Time Period	Mean Maximum Mixing Depth (M)	Mean Wind Speed (m/Sec)	Ventilation Factor (m^2/Sec)	Mean Minimum Mixing Depth (M)	Mean Wind Speed (m/Sec)	Ventilation Factor (m^2/Sec)
Annual	1359	6.2	8426	493	5.3	2613
Spring	1523	6.7	10204	503	5.6	2817
Summer	1460	5.0	7300	656	4.2	2755
Fall	1401	6.6	9247	419	5.4	2263
Winter	1052	6.4	6733	394	5.8	2285

Source: NOAA (1968); Holzworth (1972).

Table 3-16. FREQUENCY OF EPISODES FOR TAMPA, FLORIDA FROM 1960 THROUGH 1964

Month	Length of Stagnation Period			
	12 Hrs.	24 Hrs.	48 Hrs.	72 Hrs.
January	2.8	1.4	0.2	0.0
February	2.4	1.4	0.4	0.2
March	1.0	0.4	0.2	0.0
April	0.8	0.4	0.0	0.0
May	0.8	0.4	0.0	0.0
June	2.8	2.2	0.0	0.0
July	3.6	1.2	0.4	0.2
August	3.6	2.8	0.2	0.0
September	1.8	0.8	0.0	0.0
October	1.8	1.0	0.0	0.0
November	2.2	1.0	0.0	0.0
December	2.8	1.4	0.4	0.2
Annual Total	26.4	14.4	1.8	0.6

Source: NOAA (1968).

Table 3-17. SUMMARY OF AMBIENT SULFUR DIOXIDE DATA IN THE VICINITY OF THE PROPOSED FARMLAND SITE

Station	Sponsor	Time Period	Number of Observations	Concentrations (ug/m^3) Arithmetic Mean	Concentrations (ug/m^3) Maximum 24-Hour	Concentrations (ug/m^3) Second Highest 24-Hour
10-4100-001	Sarasota County	9/1/76-12/31/76	15	0	1	0
		1/1/77-12/31/77	58	3	41	17
		1/1/78-9/30/78	44	7	60	35
AQ-1	C.F. Industries	7/1/77-9/30/78	*	NA	28	22
AQ-2	C.F. Industries	7/1/77-9/30/78	*	NA	29	29
AQ-3	C.F. Industries	7/1/77-9/30/78	NA	NA	15	4
AQ-4	C.F. Industries	7/1/77-9/30/78	*	NA	32	29
AQ-5	C.F. Industries	7/1/77-9/30/78	*	NA	29	29
AQ-6	C.F. Industries	7/1/77-9/30/78	*	NA	29	29
AQ-7	C.F. Industries	7/1/77-9/30/78	*	NA	31	31
AQ-8	C.F. Industries	7/1/77-9/30/78	*	NA	31	29

NA = Not available

*Continuous monitoring conducted; actual number of samples not available.

Source: Farmland Industries, Inc. (1979).

Table 3-18. ANNUAL SO_2 MONITORING DATA SUMMARY AT THE ESTECH DUETTE MINE SITE (1977-1978).

Station	Minimum 24-Hour Average	Maximum 24-Hour Average	Second Highest 24-Hour Average	Annual Arithmetic Mean
S-1	0	50.9 (164.4)[a]	43.3	11.6 (14.6)[a]
S-2	0	51.4	45.4	10.3
S-3	0	49.1	42.6	15.0
NAAQS				
Primary			365	80
Secondary			260	60
Florida Standard			260	60

Note: Values in Micrograms per Cubic Meter

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a) Measurements at nearby monitoring sites ranged from 0 - 22.8 on 5/8/79. Inconsistent observation believed to be result of unidentifiable error.

Source: U.S. EPA (1979b).

Table 3-19. CONTINUOUS SO_2 DATA SUMMARY FOR THE CF MINING CORPORATION SITE IN HARDEE COUNTY SHOWING ONLY INCIDENTS OF HIGH CONCENTRATION.

		Maximum (µg/m^3)			
Site	Date	Hr	3-Hr	24-Hr	Wind Dir., 6-Hr
C-1	11/18/75	130	89	27	NE
C-1	12/19/75	130	113	45	NNE
C-1	12/23/75	130	91	38	ENE
C-1	1/12/76	287	187	48	NE
C-1	1/16/76	104	85	42	NW
C-1	1/19/76	120	78	41	E
C-1	4/2/76	157	131	87	NNE
C-1	4/3/76	235	141	73	N
C-2	1/12/76	261	231	50	NNE
C-2	3/17/76	183	98	26	NE
C-4	10/29/75	261	136	32	NNE
C-4	12/23/75	144	104	42	ENE
C-4	1/16/76	151	133	43	NNW
C-4	1/19/76	99	81	44	NE
C-4	1/20/76	117	89	31	NE
C-4	1/23/76	104	78	-	N
C-4	1/29/76	102	82	35	-
C-4	2/22/76	188	145	30	NW
C-5	1/5/76	117	89	26	NE
C-5	1/12/76	157	132	32	NNE
C-5	1/16/76	117	100	35	NW
C-5	1/19/76	99	72	33	NNE
C-7	1/12/76	104	80	25	NNE
C-7	1/23/76	104	77	32	N
C-7	1/29/76	104	72	34	-
C-7	3/17/76	183	107	32	NE
C-8	1/18/76	104	85	41	N
C-8	1/29/76	110	82	30	-

Source: U.S. EPA (1978).

Table 3-20. AMBIENT SO_2 LEVELS (CONTINUOUS) ON THE FARMLAND SITE JANUARY 1979 - DECEMBER 1979.

Number of Observations	Min.	Levels Measured ($\mu g/m^3$) Arith.Mean	Std.Dev.	Geo.Mean
7122	1	3.48	8.88	2.48

Maximum 1-hour Concentration = 217 $\mu g/m^3$

Maximum 3-hour Concentration = 155 $\mu g/m^3$

Maximum 24-hour Concentration = 69 $\mu g/m^3$

Source: Environmental Science and Engineering, Inc. (1980).

Table 3-21. COUNTYWIDE AVERAGES FOR ANNUAL ARITHMETIC AVERAGE OF 24-HOUR SO_2 DATA*

	Micrograms per Cubic Meter				
County	**1972**	**1973**	**1974**	**1975**	**1976****
Charlotte	--	0	--	--	0
DeSoto	--	0	0	5	1
Hillsborough	17	29	24	15	12
Manatee	11	10	5	3	2
Polk	--	21	42	10	7
Sarasota	--	3	1	1	1

-- No data.

* Chadbourne (1977).

** Data reported to mid-1976.

Source: U.S. EPA (1978).

Table 3-22. SUMMARY OF TOTAL SUSPENDED PARTICULATE MATTER DATA IN THE VICINITY OF THE PROPOSED FARMLAND SITE

Station	Sponsor	Time Period	Number of Observations	Concentrations (μg/m^3)		
				Geometric Mean	Maximum 24-Hour	Second Highest 24-Hour
10-4100-001	Sarasota County	9/1/76-12/31/76	17	25	53	46
		1/1/77-12/31/77	57	27	95	83
		1/1/78-9/30/78	43	29	73	70
MCC-1	Mississippi Chemical	7/29/75-7/29/76	94	27	62	57
MCC-2	Mississippi Chemical	7/29/75-7/29/76	80	28	90	70
AQ-1	C.F. Industries	7/1/77-9/30/78	75	27	95	75
AQ-2	C.F. Industries	7/1/77-9/30/78	74	26	147	110
AQ-3	C.F. Industries	7/1/77-9/30/78	72	23	104	58
AQ-4	C.F. Industries	7/1/77-9/30/78	75	26	78	66
AQ-5	C.F. Industries	7/1/77-9/30/78	74	22	49	44
AQ-6	C.F. Industries	7/1/77-9/30/78	75	25	71	66
AQ-7	C.F. Industries	7/1/77-9/30/78	71	28	75	68
AQ-8	C.F. Industries	7/1/77-9/30/78	74	28	207	102

Source: Farmland Industries, Inc. (1979)

Table 3-23. ANNUAL TSP SUMMARY AT THE ESTECH GENERAL CHEMICAL CORPORATION SITE IN MANATEE COUNTY, FLORIDA; 1977-1978.

Station	Minimum 24-Hr Average	Maximum 24-Hr Average	Second Maximum 24-Hr Average	Annual Geometric Mean
S-1	9	95	84[a]	25.1
S-2	6	44	41	20.0
S-3	12	122[b]	110[c]	29.2
NAAQS				
Primary			260	75
Secondary			150	60
Florida Standard			150	60

Note: Values in Micrograms per Cubic Meter

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a) Elevated value attributed to agricultural burning at numerous nearby locations, next second highest value = 54 micrograms per cubic meter.

b) Maximum value attributed to strong gusty winds predominantly from the direction of a nearby dirt road.

c) Next second highest value = 76 micrograms per cubic meter attributed to agricultural burning (see [a]), next second highest value = 64 micrograms per cubic meter.

Source: U.S. EPA (1979b).

Table 3-24. FARMLAND 24-HOUR TOTAL SUSPENDED PARTICULATE MATTER CONCENTRATIONS, STATISTICAL SUMMARY, JANUARY 15, 1979 THROUGH JANUARY 31, 1980 (Results in $\mu g/m^3$).

Station Number	Total Observations	Arithmetic Mean	Geometric Mean	Observed Maximum	Second Highest Concentration	Geometric Standard Deviation
1	55	32	28	68	67	1.79
2	54	26	23	58	51	1.69
3	59	29	27	74	61	1.55
4	24	24	21	42	38	1.76

Note: 24-hour Standard is 150 $\mu g/m^3$, not to be exceeded more than once per year.

Source: Environmental Science and Engineering, Inc. 1980.

Table 3-25. TSP LEVELS EXCEEDING 90 MICROGRAMS PER CUBIC METER AT CF MINING CORPORATION'S HARDEE COUNTY SITE.

Site	Date	24-hr ($\mu g/m^3$)	Wind Direction
10	10/8/75	107	SSE
10	10/10/75	149	ENE
2	10/19/75	91	-
10	10/22/75	135	NE
2	10/25/75	156	-
9	10/27/75	146	ENE
10	11/15/75	127	NNE
10	11/21/75	124	WNW
2	11/23/75	104	N
1	12/23/75	109	N
2	1/23/76	99	NE
8	2/11/76	90	NNW
8	2/17/76	97	S
8	3/22/76	97	NW
11	5/19/76	95	-
12	6/14/76	115	-

Source: U.S. EPA (1978).

Table 3-26. SUMMARY OF AMBIENT GASEOUS FLOURIDE DATA IN THE VICINITY OF THE PROPOSED FARMLAND SITE

Station	Sponsor	Time Period	Number of Observations	Concentrations (ug/m³) Arithmetic Mean	Maximum 24-Hour	Second Highest 24-Hour
10-4000-001	Sarasota County	9/1/76-12/31/76	16	0	0	0
		1/1/77-12/31/77	57	0	1	1
		1/1/78-9/30/78	42	0	0	0
AQ-1	C.F. Industries	7/1/77-9/30/78	76	1	22	14
AQ-2	C.F. Industries	7/1/77-9/30/78	75	1	12	10
AQ-3	C.F. Industries	7/1/77-9/30/78	75	1	11	10
AQ-4	C.F. Industries	7/1/77-9/30/78	74	1	23	8
AQ-5	C.F. Industries	7/1/77-9/30/78	75	1	10	9
AQ-6	C.F. Industries	7/1/77-9/30/78	75	1	7	5
AQ-7	C.F. Industries	7/1/77-9/30/78	73	1	21	15
AQ-8	C.F. Industries	7/1/77-9/30/78	73	1	5	2

Source: Farmland Industries, Inc. (1979).

Table 3-27. FARMLAND 24-HOUR GASEOUS FLUORIDE CONCENTRATIONS STATISTICAL SUMMARY, MARCH 29, 1979 THROUGH JANUARY 4, 1980 (Results in $\mu g/m^3$).

Station Number	Standard Dev.	Arithmetic Mean	Minimum	Observed Maximum	Second Highest	Number of Observations
1	0.31	0.84	0.7[1]	2.0	1.4[2]	45
2	0.24	0.79	0.7	1.4[2]	1.4[2]	45
3	0.30	0.84	0.7	1.9	1.4[2]	45

[1] The value 0.7 $\mu g/m^3$ was derived statistically. It is half the minimum detectable limit (1.4 $\mu g/m^3$) used after 5/12/79. It is not a measured value.

[2] The value 1.4 $\mu g/m^3$ was derived statistically. It is half the minimum detectable limit (2.8 $\mu g/m^3$) used prior to 5/12/79. It is not a measured value.

Source: Environmental Science and Engineering, Inc. 1980.

Table 3-28. FARMLAND 24-HOUR PARTICULATE FLUORIDE CONCENTRATIONS STATISTICAL SUMMARY, JANUARY 15, 1979 THROUGH JANUARY 10, 1980 (Results in $\mu g/m^3$).

Station Number	Standard Dev.	Arithmetic Mean	Minimum[1]	Observed Maximum	Second Maximum	Number of Observations
1	0.07	0.05	<0.005[1]	0.37	0.24	53
2	0.04	0.03	<0.005	0.16	0.13	49
3	0.06	0.04	<0.005	0.22	0.22	54
4	0.10	0.05	<0.005	0.40	0.20	19

[1] 0.01 $\mu g/m^3$ is the Minimum Detectable Limit (MDL) of this High Volume Filter Fluoride Procedure. 0.005 $\mu g/m^3$ was utilized in the statistical analysis for all observed values less than the MDL.

Source: Environmental Science and Engineering, Inc. 1980.

Table 3-29. ANNUAL TOTAL ATMOSPHERIC FLUORIDE SUMMARY AT THE ESTECH GENERAL CHEMICAL CORPORATION SITE IN MANATEE COUNTY, FLORIDA, 1977-1978.

Station	Minimum 24-hour Average	Maximum 24-hour Average	Maximum 30-Day	Maximum 12-Month Average
S-1	0	3.97 (4.9)	2.25 (2.8)	0.57 (0.7)
S-2	0	2.20 (2.7)	1.48 (1.8)	0.42 (0.5)
S-3	0	3.17 (3.9)	1.13 (1.4)	0.43 (0.5)
FDER, 1976 Proposed Std.		(5.6)[1]	(1.8)[1]	(0.9)[1]

Note: Values in micrograms per cubic meter and parts per billion (ppb = parenthesis)[2].

[1] Standard proposed, but not approved by FDER Commission.

[2] ppb concentrations based on 60°F temperature.

Source: U.S. EPA (1979b).

Table 3-30. **SULFUR DIOXIDE AND PARTICULATE MATTER EMISSION RATES FOR HARDEE COUNTY SOURCES.**

Source	Sulfur Dioxide		Particulate Matter	
	Tons/Year	Maximum lb/hr	Tons/Year	Maximum lb/hr
Wauchula				
Wauchula Power 1-4	5.0	1.1	25.0	5.7
American Orange Co.				
Peel Dryer	75.0	37.2	15.1	7.5
Peel Dryer	125.0	62.0	25.2	12.5
Boilers	43.6	13.0	3.6	1.1
Zolfo Springs				
Mancini Packing				
Propane Boiler	7.3	4.7	0.6	0.4
Pepper Roaster	--	--	8.9	5.7

Source: Environmental Science and Engineering, Inc. (1980).

Table 3-31. NOISE LEVELS (dBA) IN THE VICINITY OF THE PROPOSED FARMLAND SITE, FALL 1979.

Location[1]	Season	Period of Measurement (Mo/Day/Yr--Hr [EDT])	L_d	L_n	$L_{eq(24)}$[2] L_{dn}
1	Fall	09/26/79 - 1030	62.5	----	62.3
		09/26/79 - 2200	----	61.9	
		09/27/79 - 1745	42.2	----	44.6
		09/28/79 - 0515	----	48.6	
2	Fall	09/26/79 - 1100	64.9	----	67.5
		09/26/79 - 2230	----	71.7	
		09/27/79 - 1800	76.0	----	73.8
		09/28/79 - 0405	----	70.0	
3	Fall	09/26/79 - 1145	49.1	----	63.7
		09/26/79 - 2310	----	88.1	
		09/27/79 - 1845	40.2	----	47.8
		09/28/79 - 0435	----	60.4	
4	Fall	09/26/79 - 1230	63.7	----	63.3
		09/26/79 - 2340	----	62.6	
		09/27/79 - 1930	46.0	----	51.1
		09/28/79 - 0335	----	59.7	
5	Fall	09/26/79 - 1304	64.4	----	63.1
		09/27/79 - 0020	----	60.9	
		09/27/79 - 2000	70.6	----	67.6
		09/28/79 - 0300	----	62.5	
6	Fall	09/26/79 - 1350	70.1	----	70.0
		09/27/79 - 0100	----	69.9	
		09/27/79 - 2045	60.3	----	71.4
		09/28/79 - 0545	----	89.9	
				Average	62.2

---

[1] See Figure 4-1 for station locations.

[2] Estimated values from weighted $L_{eq(18)}$ measured values.

A-weighted Descriptors:

- Equivalent Sound Level = L_{eq}
- Equivalent Sound Level Over Time (T) = $L_{eq(T)}$
- Day Sound Level = L_d
- Night Sound Level = L_n
- Day-Night Sound Level = L_{dn}
- Yearly Day-Night Sound Level = $L_{dn(y)}$

Table 3-32. NOISE LEVELS (dBA) IN THE VICINITY OF THE PROPOSED FARMLAND SITE, WINTER 1980.

Location[1]	Season	Period of Measurement (Mo/Day/Yr--Hr [EDT])	L_d	L_n	$L_{eq(24)}$[2] L_{dn}
1	Winter	01/14/80 - 0530	----	40.4	
		01/14/80 - 1525	48.6	----	45.5
		01/15/80 - 0025	----	45.5	
		01/15/80 - 0845	45.4	----	45.4
2	Winter	01/14/80 - 0430	----	59.9	
		01/14/80 - 1425	59.1	----	59.4
		01/14/80 - 2300	----	42.2	
		01/15/80 - 0730	58.8	----	52.6
3	Winter	01/14/80 - 0500	----	54.1	
		01/14/80 - 1455	41.7	----	46.4
		01/15/80 - 0005	----	49.9	
		01/15/80 - 0815	47.1	----	48.2
4	Winter	01/14/80 - 0400	----	41.1	
		01/14/80 - 1400	53.9	----	49.1
		01/14/80 - 2235	----	47.3	
		01/15/80 - 0915	40.8	----	43.2
5	Winter	01/14/80 - 0330	----	38.0	
		01/14/80 - 1335	63.4	----	53.9
		01/14/80 - 2205	----	56.7	
		01/15/80 - 0945	57.4	----	57.1
6	Winter	01/14/80 - 0300	----	55.3	
		01/14/80 - 1555	65.6	----	61.7
		01/15/80 - 0055	----	62.5	
		01/15/80 - 0705	57.3	----	59.3
				Average	51.8

---

[1] See Figure 4-1 for station locations.

[2] Estimated values from weighted $L_{eq(18)}$ measured values.

A-weighted Descriptors:

- Equivalent Sound Level - L_{eq}
- Equivalent Sound Level Over Time (T) = $L_{eq(T)}$
- Day Sound Level = L_d
- Night Sound Level = L_n
- Day-Night Sound Level = L_{dn}
- Yearly Day-Night Sound Level = $L_{dn(y)}$

4.0
GEOLOGY AND SOILS

4.1 THE AFFECTED ENVIRONMENT

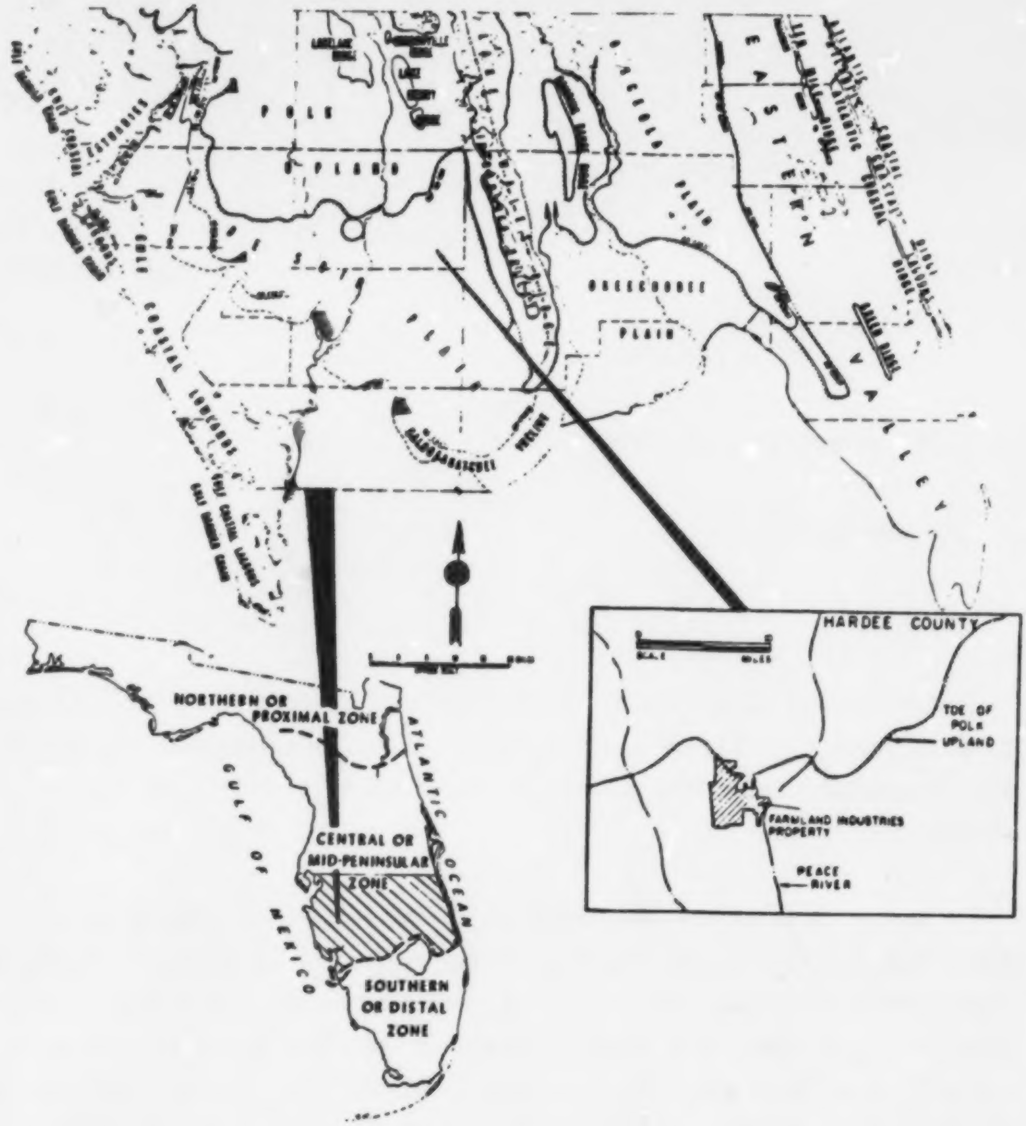
4.1.1 GEOLOGY

PHYSIOGRAPHY

The Florida peninsula has been divided into three general physiographic provinces (Figure 4-1) by White (1970), and includes the northern or proximal zone, the central or mid-peninsular zone, and the southern or distal zone.

The northern or proximal zone is characterized by a broad upland extending eastward to the eastern valley and westward into the western highlands of Florida. The central or mid-peninsular zone consists of sub-parallel ridges with broad intervening valleys, together forming a discontinuous highland. The southern or distal zone is characterized by a broad, flat, gently sloping and poorly drained plain (White 1970).

The site for Farmland's proposed phosphate mine is located in the southwestern portion of the mid-peninsular physiographic zone on the DeSoto Plain just south of the Polk Upland (Figure 4-1). The Polk Upland is generally at elevations between 100 and 130 feet except for the ridges along the eastern boundary which rise 25 to 50 feet above the upland, and the toe of the scarp separating the Polk Upland from the



POLK
UPLAND
OKEECHOBEE
PLAIN
EASTERN
VALLEY
HARDEE COUNTY
TOE OF POLK UPLAND
FARMLAND INDUSTRIES PROPERTY
PEACE RIVER
NORTHERN OR PROXIMAL ZONE
ATLANTIC OCEAN
GULF OF MEXICO
CENTRAL OR MID-PENINSULAR ZONE
SOUTHERN OR DISTAL ZONE

FIGURE 4-1. SITE AREA PHYSIOGRAPHY.

SOURCE: ADAPTED FROM WHITE, THE GEOMORPHOLOGY OF THE FLORIDA PENINSULA (1970).

DeSoto Plain which is 75 to 80 feet in elevation. Topographic dissection amounts to some 50 feet in the Polk Upland whereas the DeSoto Plain shows appreciably less (White 1970).

The origin of the scarp separating the Polk Upland from the DeSoto Plain is uncertain but likely represents a past marine erosional limit of the Gulf of Mexico.

Karst topography is variably developed in the upland area whereas the DeSoto Plain displays few solution related features. The difference in karst development appears to be related to thickness of overburden above solution susceptible units and depth of the potentiometric surface. The site area is underlain by a thick (95- to 110-foot) layer of predominantly clastic sediments above the Hawthorn Formation and deeper solution prone limestones with the water table at or near the surface. Both these factors significantly reduce the potential for development of solution features. Although collapse and erosion sinks are not characteristic of the site area, solution sinks or dolines are likely to occur. The results of such processes involve the lowering of the ground surface at a rate of about 1-foot per 5000 to 6000 years and should cause little or no effects during the life of the mine at this site.

STRATIGRAPHY

It has been found from drill hole data that Precambrian, Paleozoic, and lower Mesozoic age rocks underlie Florida at great depths (Puri and Vernon 1964). Following formation of the Peninsular arch, in mid-Mesozoic time, probable Jurassic and Cretaceous sediments were deposited in the Gulf Coast geosyncline (Figure 4-2). Depth below sea level to the Coastal Plain floor ranges from about 2600 feet in northern Florida to more than 12,500 feet in the vicinity of Lake Okeechobee (Puri and Vernon 1964). Late Mesozoic sediments are chiefly clastic deposits, whereas younger Cenozoic deposits are predominantly nonclastic.

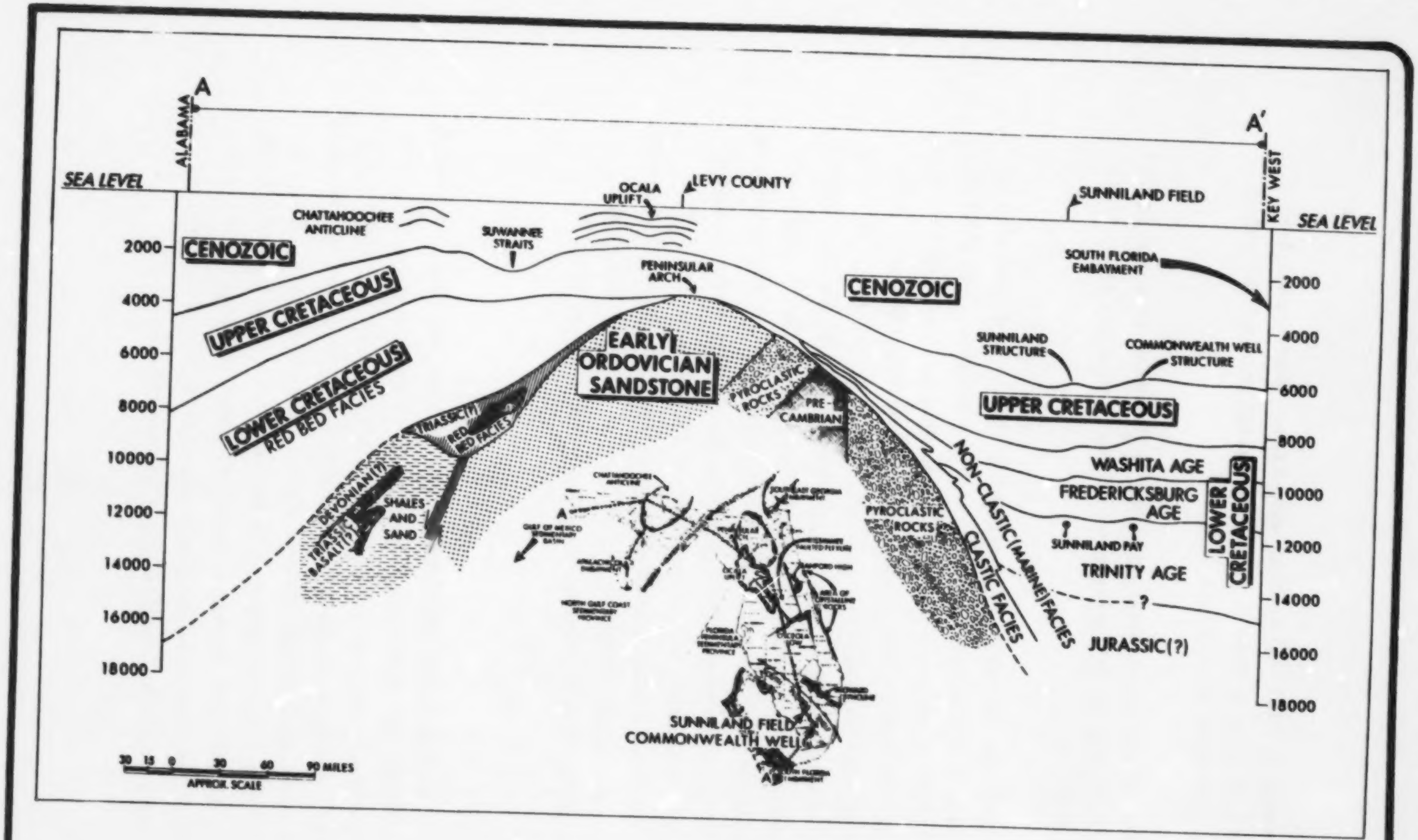

A
ALABAMA
A'
KEY WEST
SEA LEVEL
SEA LEVEL
OCALA UPLIFT
LEVY COUNTY
SUNNILAND FIELD
CHATTAHOOCHEE ANTICLINE
SUWANNEE STRAITS
PENINSULAR ARCH
SOUTH FLORIDA EMBAYMENT
CENOZOIC
UPPER CRETACEOUS
LOWER CRETACEOUS
RED BED FACIES
CENOZOIC
EARLY ORDOVICIAN SANDSTONE
PYROCLASTIC ROCKS
PRE-CAMBRIAN
TRIASSIC(?) RED BED FACIES
DEVONIAN(?)
TRIASSIC(?) BASALT(?)
SHALES AND SAND
SUNNILAND STRUCTURE
COMMONWEALTH WELL STRUCTURE
UPPER CRETACEOUS
WASHITA AGE
FREDERICKSBURG AGE
LOWER CRETACEOUS
SUNNILAND PAY
TRINITY AGE
?
JURASSIC(?)
NON-CLASTIC (MARINE) FACIES
CLASTIC FACIES
PYROCLASTIC ROCKS
SUNNILAND FIELD
COMMONWEALTH WELL
A
A'
2000
4000
6000
8000
10000
12000
14000
16000
18000
30 15 0 30 60 90 MILES
APPROX. SCALE

FIGURE 4-2. GENERALIZED GEOLOGIC CROSS SECTION THROUGH FLORIDA.

SOURCE: PURI AND VERNON, SUMMARY OF THE GEOLOGY OF FLORIDA (1964).

In Hardee County, Cenozoic deposits begin with the Avon Park Limestone of Middle Eocene age which unconformably overlies the Mesozoic clastic sequence; see Table 4-1; Figure 4-3. Unconformably overlying the Avon Park Limestone is the Ocala Group of Upper Eocene age, consisting predominantly of limestone and dolomite. The Oligocene age Suwannee Limestone unconformably overlies the Ocala Group and, in turn, is unconformably overlain by the Lower Miocene Tampa Formation. The Tampa Formation consists of a lower sand and clay unit overlain by a limestone upper unit. The lower sand and clay beds form the confining unit between the Floridan Aquifer below and the Secondary Artesian Aquifer above (P.E. LaMoreaux & Associates, Inc. 1978).

Unconformably overlying the Tampa Formation is the Hawthorn Formation of Miocene age. This formation consists chiefly of sandy phosphatic limestone, with marl, dolomite, and limestone in the upper portion. Overlying the Hawthorn Formation is undifferentiated Pliocene to Recent sandy clay to silty sand varying in carbonate and phosphate content (Table 4-1).

STRUCTURE AND GEOLOGIC SETTING

Florida lies within the Gulf of Mexico sedimentary basin. Northwestern Florida is in the North Gulf Coast sedimentary province and contains largely clastic sediments. The remainder of the state is underlain by predominantly nonclastic carbonates and anhydrites of the Florida Peninsula sedimentary province (Figure 4-4) (Puri and Vernon 1964).

The dominant subsurface structure is the Peninsular arch, a Paleozoic-Mesozoic feature which was modified in early Miocene time by the Ocala uplift, Chattahoochee anticline, Kissimmee faulted flexure, Sanford high, Osceola low, and other shallow features (Puri and Vernon 1964). The site lies in the Osceola low south of the Kissimmee faulted

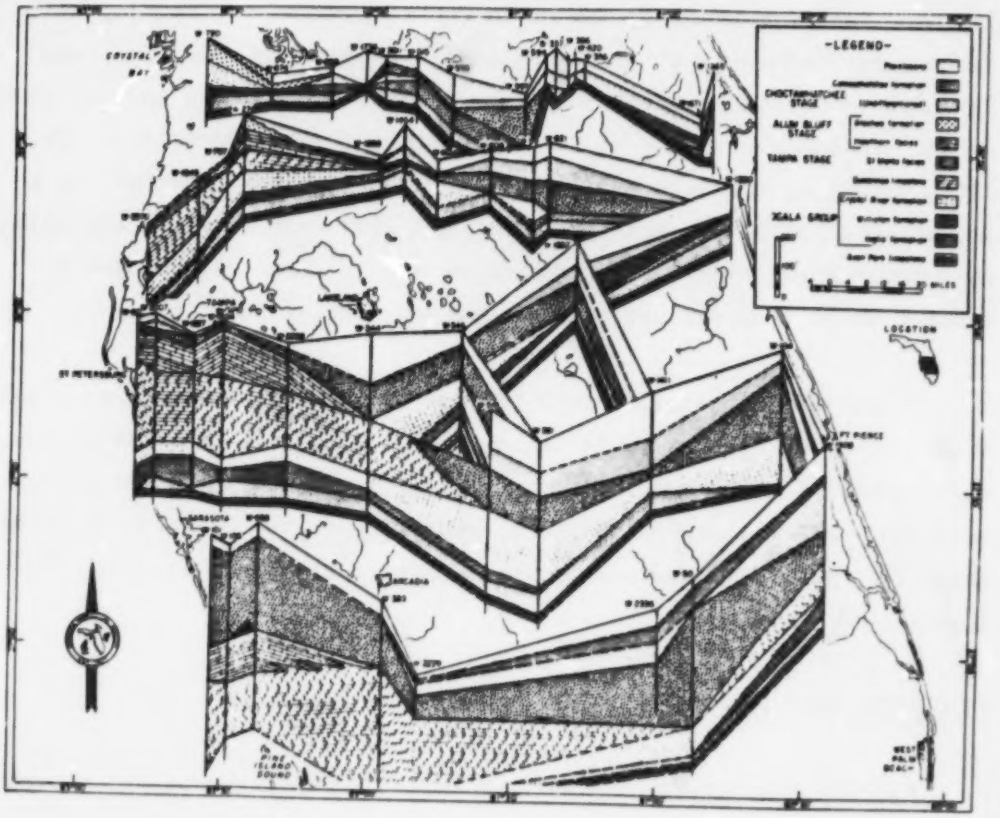

-LEGEND-
CHOCTAWHATCHEE STAGE
ALUM BLUFF STAGE
TAMPA STAGE
OCALA GROUP
MILES
LOCATION
CRYSTAL BAY
TAMPA
ST PETERSBURG
SARASOTA
ARCADIA
FORT PIERCE
PINE ISLAND SOUND
WEST PALM BEACH

FIGURE 4-3. PANEL DIAGRAM OF THE POST--AVON PARK ROCKS IN CENTRAL FLORIDA.

SOURCE: PURI AND VERNON, SUMMARY OF THE GEOLOGY OF FLORIDA (1964).

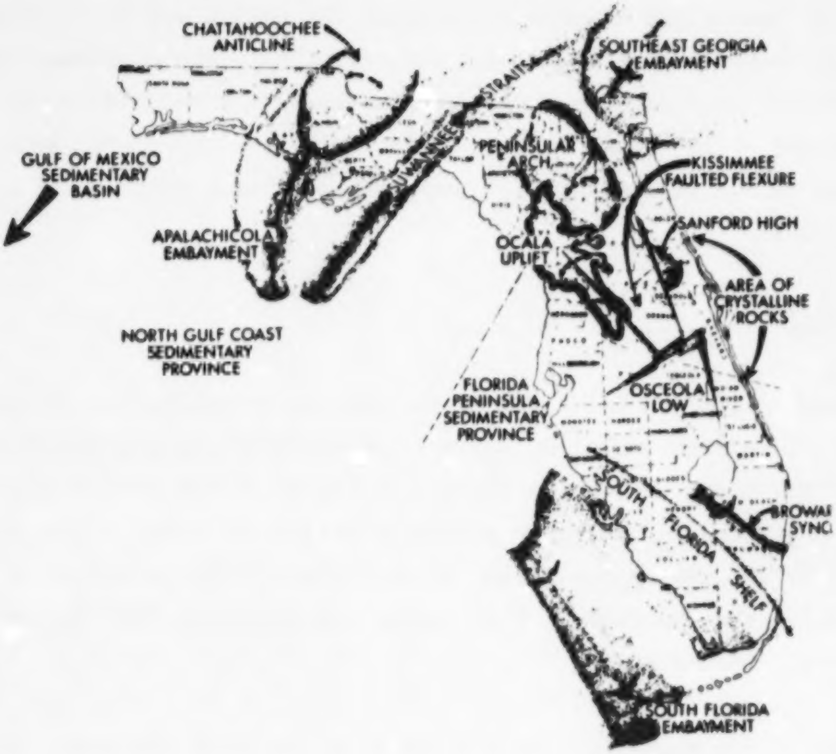

CHATTAHOOCHEE ANTICLINE
SOUTHEAST GEORGIA EMBAYMENT
GULF OF MEXICO SEDIMENTARY BASIN
SUWANNEE STRAITS
PENINSULAR ARCH
KISSIMMEE FAULTED FLEXURE
APALACHICOLA EMBAYMENT
OCALA UPLIFT
SANFORD HIGH
AREA OF CRYSTALLINE ROCKS
NORTH GULF COAST SEDIMENTARY PROVINCE
FLORIDA PENINSULA SEDIMENTARY PROVINCE
OSCEOLA LOW
SOUTH FLORIDA SHELF
BROWA
SYNC
SOUTH FLORIDA EMBAYMENT

FIGURE 4-4. INDEX TO PRINCIPAL GEOLOGIC STRUCTURES IN FLORIDA.

SOURCE: PURI AND VERNON, SUMMARY OF THE GEOLOGY OF FLORIDA (1964).

flexure and on the southwest flank of the southeasterly plunging Ocala uplift. The Ocala uplift strongly influenced sedimentation in this area. Oligocene and Miocene units flank the uplift and are relatively thick in contrast to Pliocene and younger units. The Kissimmee faulted flexure is a northeast trending feature apparently related to the development of the Ocala uplift. This fault resulted in the downdropping of the Osceola low and forms the northwest boundary of the low (Figure 4-4).

SEISMICITY

Most of the Coastal Plain of the eastern United States, including Florida, is characterized by low seismic activity (Hadley and Devine 1974). The State of Florida itself is largely aseismic with only a few widely scattered events reported within historical time. Less than an average of two events per degree squared (about 1000 km^2) have been reported, with a maximum of five events per degree squared in the northeast corner of the state.

The events themselves were relatively low level and minor in their effects. No events above an intensity of Modified Mercalli (MM) IV have been reported from within the state, and no events MM III or above have been reported within 50 km of the site.

The greatest potential for vibratory ground motion at the site would not derive from events within the state but rather from larger events originating in more distant source areas such as Charleston, South Carolina, a distance of 600 km from the site. Large distant events could generate ground motion as strong as MM V in the site area (Bollinger 1977).

GEOLOGIC CONDITIONS AT THE MINE SITE

The Farmland mine site is located west of the Peace River in southwestern Hardee County, Florida (Sections 26, 27, 34, 35, and 36 of Township 34 South, Range 24 East; Sections 1, 2, 3, 4, 9, 10, 11, 12, 14, and 15 of Township 35 South, Range 24 East; and Sections 7 and 18 of Township 35 South, Range 25 East).

The ore body consists of the upper portion of the Miocene age Hawthorn Formation (Table 4-1). The mineable ore varies in quality and quantity over the site, averaging about 20 feet in thickness and lies beneath an equally thick overburden layer consisting chiefly of sand and clayey sand (Figure 4-5). The base of the ore zone varies in elevation above mean sea level across the site from below 10 feet in the eastern portion of the site to above 60 feet in the northern and western portions (Figure 4-6).

4.1.2 SOILS

Soils found on the Farmland mine site are representative of large areas of Hardee and surrounding Counties. Soil types in the area of the proposed mine site were mapped in 1950 by the U.S. Department of Agriculture (USDA) Soil Conservation Service (SCS). Subsequent to this mapping, a broader, more general mapping of Hardee County soil associations was compiled for the Florida General Soils Atlas prepared by the Florida Department of Administration in 1975. A modern detailed soil survey of Hardee County soils is now being conducted by the USDA SCS, with soils being mapped at the series level. Approximately 1263 acres of the northern portion of the mine site (Sections 27, 28, 34, 35, and part of 36) have been recently mapped to date. Detailed information about this recent soil mapping is presented in the SCS's Interim Soil Survey Report, Hardee County, Florida, 1979.

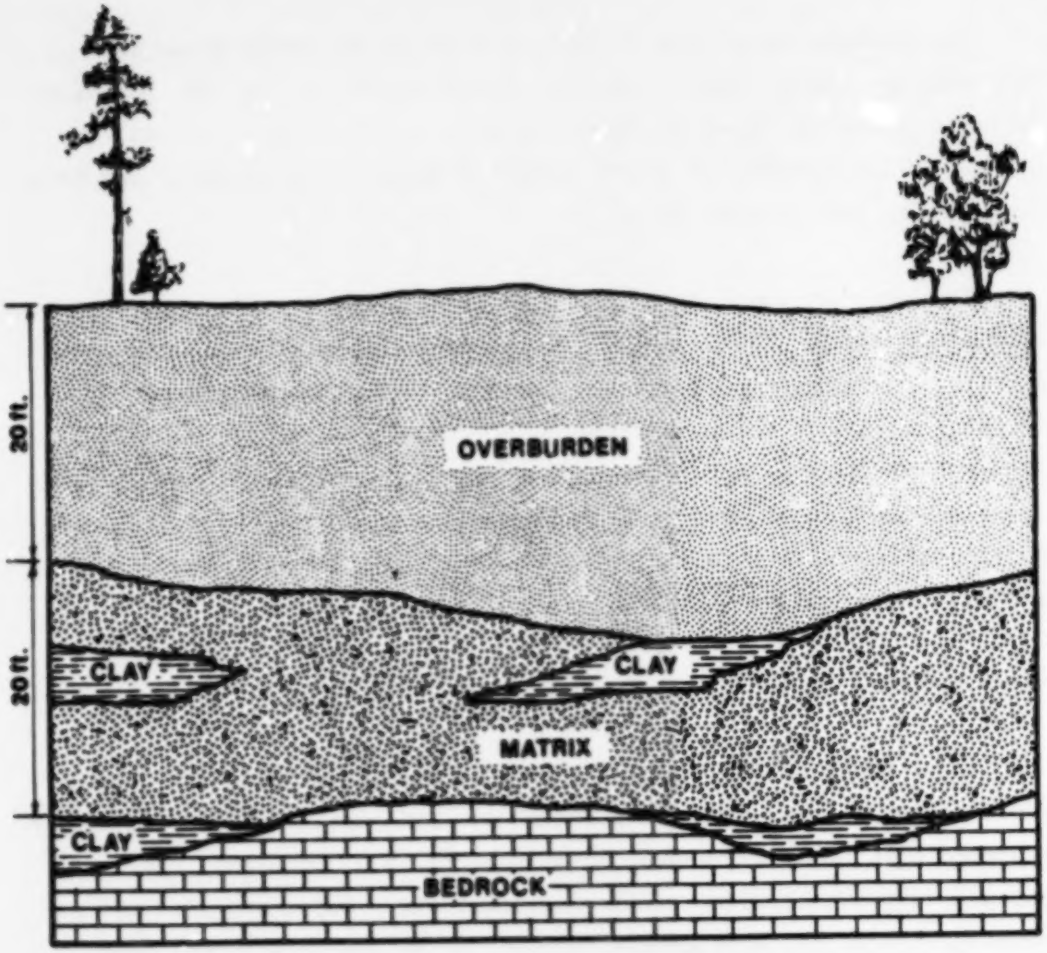

20 ft.
20 ft.
OVERBURDEN
CLAY
CLAY
MATRIX
CLAY
BEDROCK

FIGURE 4-5. GENERALIZED SECTION THROUGH MINE AREA.

SOURCE: FARMLAND INDUSTRIES, INC., HARDEE COUNTY MASTER PLAN, JUNE 1979

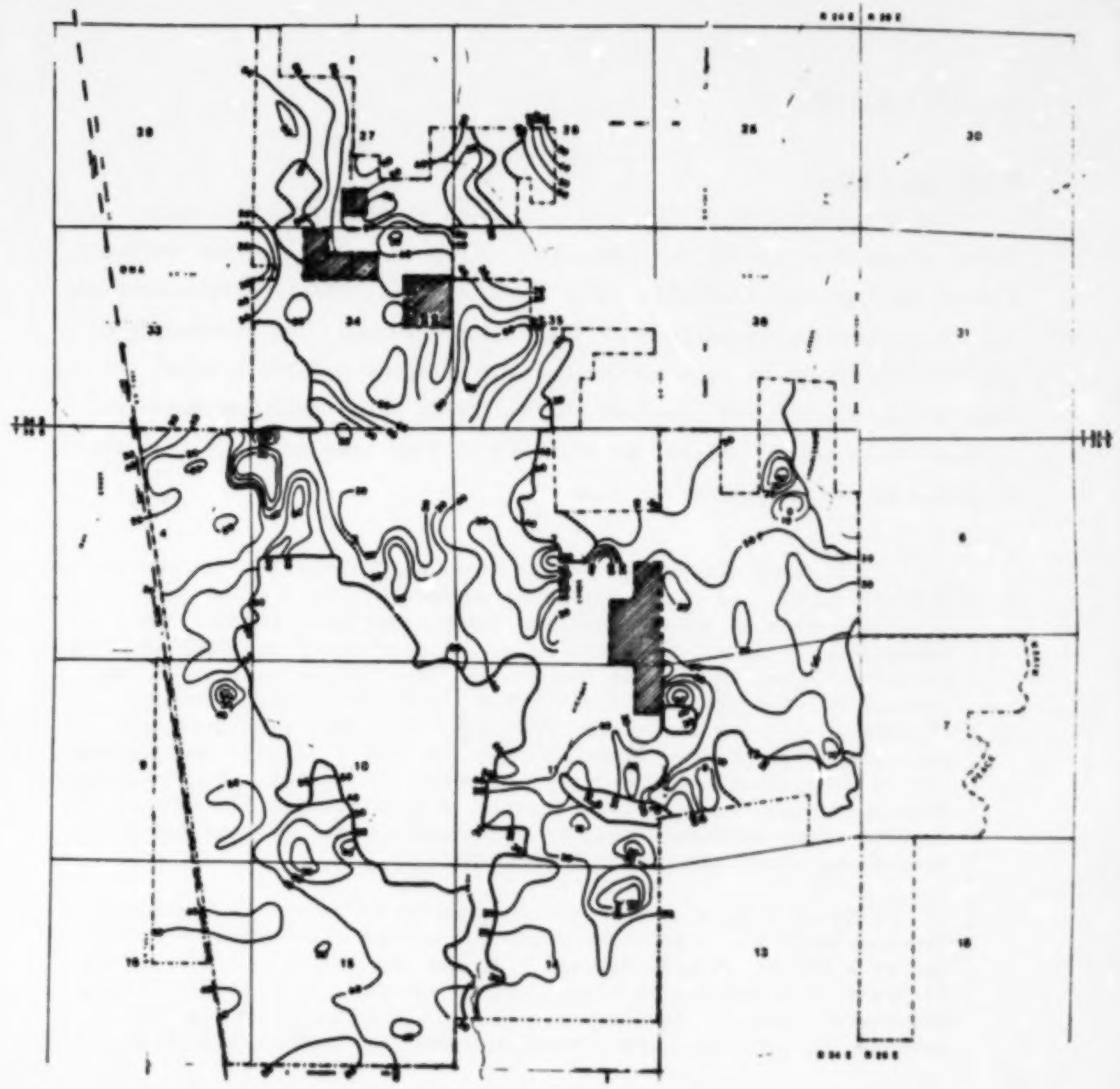

28
27
26
25
30
33
34
35
36
31
10
7
15
13
18
PROPERTY BOUNDARY
OUTPARCEL (NOT FARMLAND PROPERTY)
ELEVATION IN FEET (MEAN SEA LEVEL DATUM)
AREAS NOT TO BE MINED
N
0
2,000
4,000
SCALE IN FEET

FIGURE 4-6. STRUCTURAL CONTOURS ON BASE OF ORE BODY.

SOURCE: FARMLAND INDUSTRIES, INC., HARDEE COUNTY MASTER PLAN, JUNE 1979

SOIL DISTRIBUTION

1950 Soil Survey

The distributions of SCS soil series on the Farmland mine site based on the 1950 survey are presented in Figure 4-7. The 1950 survey showed the Leon and Immokalee soils to be the most widely distributed on the site, covering 54 percent of the onsite acreage. The percentage of the sites occupied by each series mapped in Figure 4-7 and a brief description of each are provided in Table 4-2. The following description of these soils (as well as the Blanton fine sand type) is from the Farmland Hardee County Master Plan:

> ".....Both soil types are strongly acid sands low in organic matter, clays, and plant-available nutrients. Both soils are underlain with an organic hardpan which restricts drainage and makes them prone to waterlogging during periods of wet weather. On the other hand, the coarse texture and low organic content of the surface horizon give these soils low moisture-holding capacity; therefore, despite restricted drainage, they are quite droughty during periods of low rainfall. The low levels of clay and organic matter also result in low cation exchange capacities. These soils, therefore, tend to have low retention capacities for all major applied plant nutrients, except phosphorous which is retained by mechanisms other than cationic adsorption.
>
> Blanton fine sand is also represented by substantial acreage. Blanton lacks the organic hardpan of the Leon and Immokalee soils and as a result is well-drained. In its natural state, Blanton is strongly acid and low in clay, organic matter, and plant-available nutrients. Due to its sandy texture and absence of an organic hardpan, Blanton also has a very low moisture-holding capacity.
>
> Despite their limitations, the Leon, Immokalee, and Blanton soils are the soils of greatest agricultural importance on the site. With proper drainage, liming, fertilization, and irrigation practices, these soils can be productive for a variety of agricultural uses. However, due to their limitations, a relatively high level of economic input is required to maintain their productivity.
>
> The proposed mine tract also includes a substantial acreage of soil types associated with wetland areas. Since these wetland areas serve as nutrient and sediment sinks for the surrounding upland areas, the soils associated with them tend to be higher in

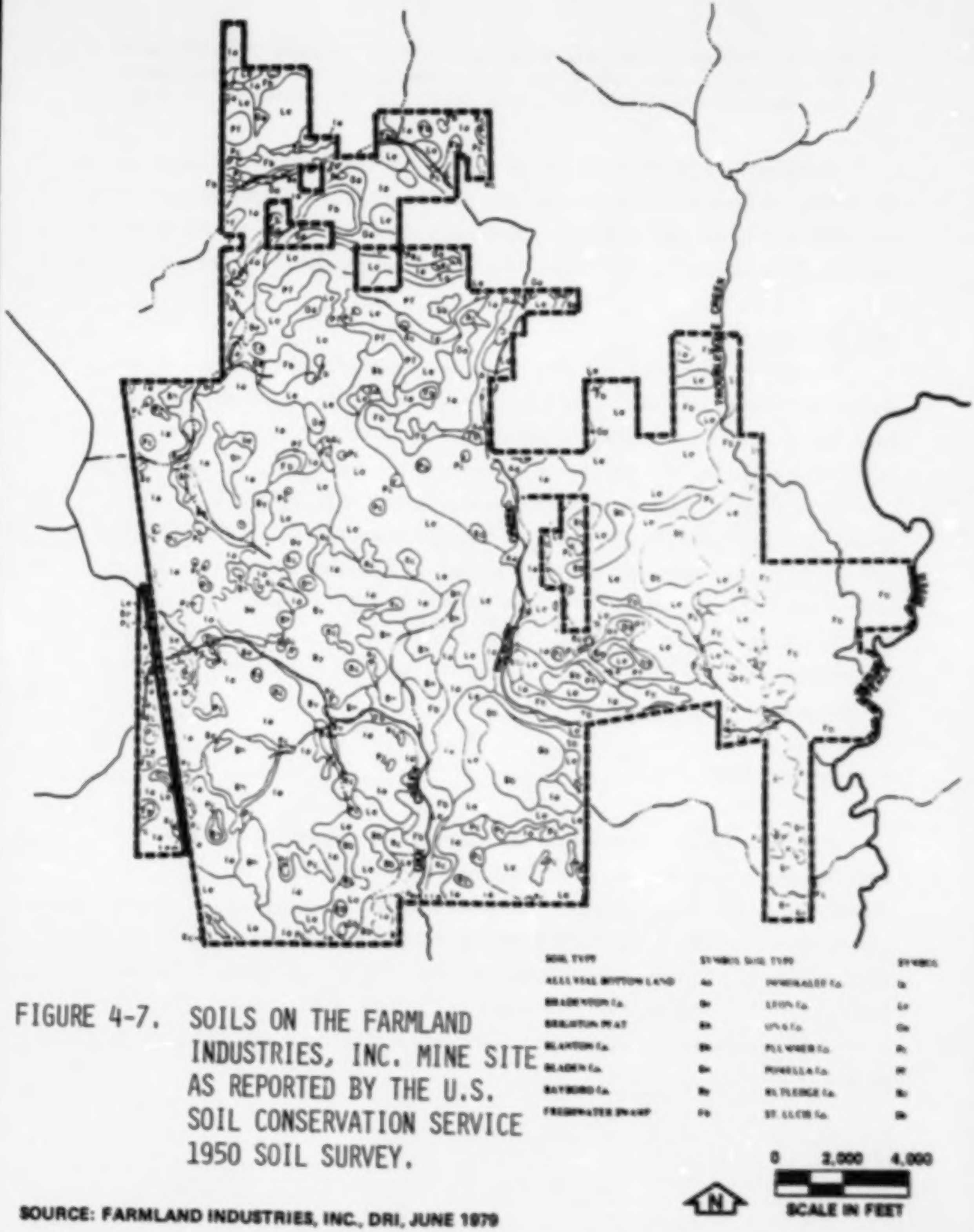

SOIL TYPE
SYMBOL
ALLUVIAL BOTTOM LAND
Ab
BRADENTON Co.
Br
BRIGHTON PEAT
Bn
BLANTON Co.
Bb
BLADEN Co.
Bn
BAYBORO Co.
By
FRESHWATER SWAMP
Fs
IMMOKALEE Co.
Im
LEON Co.
Lo
ONA Co.
On
PLUMMER Co.
Pl
POMELLO Co.
Pf
RUTLEDGE Co.
Ru
ST. LUCIE Co.
Sn
0
2,000
4,000
SCALE IN FEET
N

FIGURE 4-7. SOILS ON THE FARMLAND INDUSTRIES, INC. MINE SITE AS REPORTED BY THE U.S. SOIL CONSERVATION SERVICE 1950 SOIL SURVEY.

SOURCE: FARMLAND INDUSTRIES, INC., DRI, JUNE 1979

organic matter, clay, and plant-available nutrients than the more upland soils. Wetland soils, as a rule, have not been developed for agriculture because they are difficult and expensive to drain."

Characteristics of other soils mapped for the 1950 soil survey at the Farmland mine site as well as the relationship of series mapped for the 1950 survey to the revised series mapped on a portion of the site for the 1979 survey are provided in the next section.

1979 Soil Survey

As indicated above, the SCS is currently conducting a new soil survey of Hardee County. However, to date only 1263 acres of the mine site (in the northern portion) have been remapped. This new survey involves remapping the area at the phase of series level, using the soil taxonomic classifications system established in 1975 by the SCS. Soils Survey and Soil Map Unit Names that are the same in the 1950 and 1979 surveys are generally similar but may not be the same soils because of soil classification systems changes between these two dates. That portion of the mine site which has been remapped is shown in Figure 4-8. The characteristics of soils as mapped in the 1979 survey are presented in the next section.

SOIL DESCRIPTIONS

This section presents detailed information regarding the distribution, usage, and physical and chemical characteristics of soils occurring on the Farmland site. The descriptions are presented in the alphabetical order of the soil names as listed in Figures 4-7 and 4-8 of this document. Figure 4-7 is based on the 1950 classification, while Figure 4-8 is based on the 1979 reclassification (which covers only a portion of the site). Additional profile descriptions are provided in Appendix E.

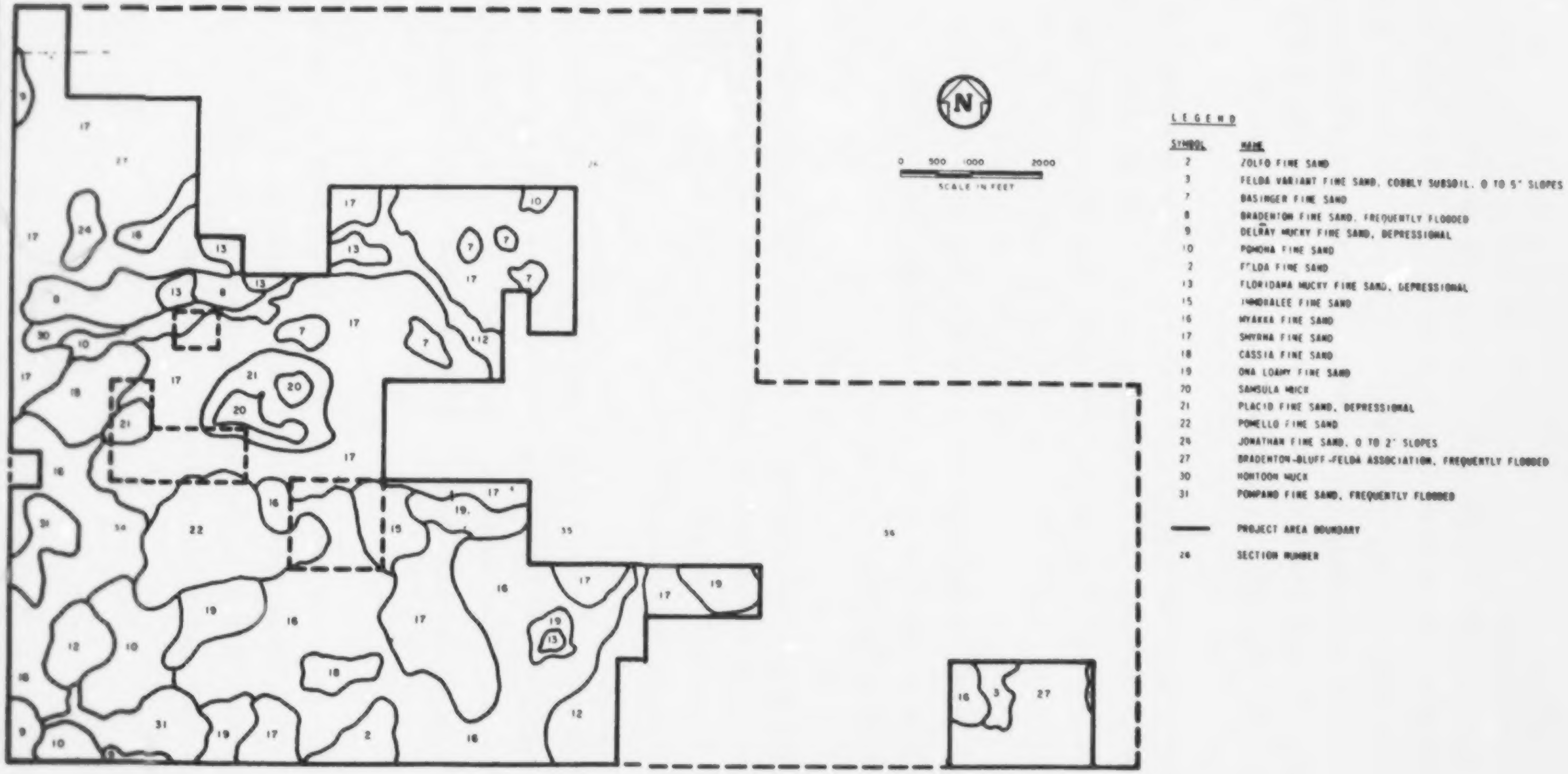

N
0 500 1000 2000
SCALE IN FEET
LEGEND
SYMBOL NAME
2 ZOLFO FINE SAND
3 FELDA VARIANT FINE SAND, COBBLY SUBSOIL, 0 TO 5% SLOPES
7 BASINGER FINE SAND
8 BRADENTON FINE SAND, FREQUENTLY FLOODED
9 DELRAY MUCKY FINE SAND, DEPRESSIONAL
10 POMONA FINE SAND
12 FELDA FINE SAND
13 FLORIDANA MUCKY FINE SAND, DEPRESSIONAL
15 IMMOKALEE FINE SAND
16 MYAKKA FINE SAND
17 SMYRNA FINE SAND
18 CASSIA FINE SAND
19 ONA LOAMY FINE SAND
20 SAMSULA MUCK
21 PLACID FINE SAND, DEPRESSIONAL
22 POMELLO FINE SAND
24 JONATHAN FINE SAND, 0 TO 2% SLOPES
27 BRADENTON-BLUFF-FELDA ASSOCIATION, FREQUENTLY FLOODED
30 HONTOON MUCK
31 POMPANO FINE SAND, FREQUENTLY FLOODED
PROJECT AREA BOUNDARY
26 SECTION NUMBER

FIGURE 4-8. SOILS ON THE PORTION OF FARMLAND INDUSTRIES, INC. MINE SITE WHICH WAS REMAPPED IN 1979.

SOURCE: USDA, SOIL CONSERVATION SERVICE, INTERIM SOIL SURVEY REPORT, HARDEE COUNTY, FLORIDA (1979).

The 1950 Soil Survey

Alluvial Bottom Land. Designation of this soil has been changed to the Bradenton-Bluff-Felda Association, Frequently Flooded in the 1979 survey. This association consists of poorly and very poorly drained soils in regular and repeating patterns along streams and rivers subject to flooding. Slopes are less than 2 percent. Bradenton, Bluff, and Felda soils are described in the next section (1979 survey).

Bayboro Fine Sand. Designation of this soil has been changed to the Delray Mucky Fine Sand, Depressional and the Floridana Mucky Fine Sand, Depressional in the 1979 survey. See this discussion under the next section.

Bladen Fine Sand. Designation of this soil has been changed to the Bradenton Fine Sand, Frequently Flooded in the 1979 survey. See this discussion under the next section.

Blanton Fine Sand. Designation of this soil has been changed to the Tavares Fine Sand 0-5 percent slopes and/or the Zolfo Fine Sand. The Zolfo Fine Sand is discussed as part of the 1979 survey in the following section. Tavares soils are discussed below.

Tavares soils are in nearly level to sloping landscapes, with slopes ranging from 0-8 percent. The soil formed in a thick bed of sandy marine or eolian deposits. Near the type location average annual precipitation is about 55 inches and mean annual temperature is about 73°F.

Tavares soils are moderately well drained. Surface runoff is slow. Permeability is very rapid. Water table is between 40 and 80 inch depths for more than 6 months during most years, but recedes to depths greater than 80 inches during droughty periods.

Most of the soil is used for citrus. A few areas are used for corn, vegetable crops, watermelons and improved pasture. In most places, natural vegetation consists of slash and longleaf pine; there are a few scattered blackjack, turkey and post oak with an undercover of pineland three-awn. In some places, natural vegetation consists of turkey oak, blackjack oak and post oak with scattered slash and longleaf pine. A soil profile description of this soil is provided in Appendix E.

Bradenton Fine Sand. These soils are discussed under Bradenton Fine Sand, Frequently Flooded in the next section.

Brighton Peat. Designation of this soil has been changed to the Tomoka Muck and/or Samsula Muck. The Samsula Muck is discussed as part of the 1979 survey in the next section. The Tomoka Muck is discussed below.

Tomoka soils are in broad low flats, fresh water marshes and swamps. Gradients are less than 2 percent. They have formed in moderately thick beds of hydrophytic non-woody plant remains. Rainfall is about 55 inches annually; mean annual air temperature is about 74°F, near the type location.

These soils are very poorly drained. Runoff is very slow. Permeability is moderate to moderately rapid. A water control system regulates the water table according to plant needs. In undrained areas the water table is at or on the surface of the soil except during extended dry periods.

Some areas are cleared and used for truck, corn, sod crops and improved pasture. Uncleared areas are used for water storage and as a wildlife habitat. Native vegetation is sawgrass, lilies, reeds, sedges, myrtle and other aquatic plants. Cypress, red and white bay, maple and pond pine are common tree species. A soil profile description of this soil is provided in Appendix E.

Freshwater Swamp. Designation of this soil has been changed to the Bradenton-Bluff-Felda Association in the 1979 survey. See this discussion under the next section.

Immokalee Fine Sand. This soil is discussed under Immokalee Fine Sand in the next section.

Leon Fine Sand. Designation of this soil has been changed to the Myakka Fine Sand in the 1979 survey. See this discussion under the next section.

Ona Fine Sand. This soil is slightly coarser textured than the Ona Loamy Fine Sand mapped in 1979 and described in the next section.

Plummer Fine Sand. No detailed standard series description has been developed for this soil type. However, the description of the Placid Fine Sand, Depressional (see the next section) is considered to be similar.

Pomella Fine Sand. This soil is discussed under Pomello Fine Sand in the next section.

Rutledge Fine Sand. Designation of this soil has been changed to Placid Fine Sand in the 1979 survey. See this discussion under the next section.

St. Lucie Fine Sand. St. Lucie Fine Sand is located on nearly level to strongly sloping dune-like ridges and on isolated knolls. Slopes range from 0-12 percent. The soil formed in marine or eolian sand. Average annual precipitation ranges from 50 to 70 inches and the mean annual air temperature is more than 79°F at the type location.

These soils are excessively drained. Internal drainage and permeability are very rapid, but there is little or no surface runoff. Depths to the seasonal water table is 72 to 120 inches.

Some of the soil is used for building sites and as a source of sand for concrete, but most of it is in scrub forest. Vegetation is namely sand live oak and sand pine, dwarf willow and some saw palmetto, rosemary, prickly pear cactus and lichens. A soil profile description for this soil is provided in Appendix E.

The 1979 Soil Survey

Basinger Fine Sand. The Basinger soils normally occur in sloughs, depressions or poorly defined drainageways. Gradients are less than 2 percent. The soil formed in a thick bed of marine sands. At the type location the average annual rainfall is 48 inches, but ranges to 60 or 70 inches. Mean annual temperature is about 73°F.

Basinger soils are poorly drained; surface runoff is slow. Permeability is very rapid. The water table is at depths of less than 10 inches for 2 to 6 months annually and at depths of 10 to 30 inches for periods of more than 6 months in most years. Depressions are covered with standing water for periods of 6 to 9 months or more in most years.

Most of the cleared acreage is used for range. With water control, the soils are used for winter truck crops and improved pasture. Natural vegetation consists of wax myrtle, St. Johnswort, cypress, slash, longleaf and pond pines and pineland three-awn. A soil profile description for this soil is provided in Appendix E.

Bluff Sandy Clay. The Bluff soils are very poorly drained with slow permeability and slow runoff. The water table is at depths of less than 10 inches for 6 or more months and seldom recedes to depths of more than 20 inches. These soils are subject to frequent flooding for long duration but do not receive appreciable sediments.

These soils are in native vegetation of hardwood growth, swamp white oak, tupello gum, swamp maple cypress and palm with scattered loblolly pine occurring in some areas. Understory vegetation consists of several blue stem species, hairy panicum, longleaf uniola vines and forbs. A soil profile description for this soil is provided in Appendix E.

Bradenton Fine Sand, Frequently Flooded. The Bradenton soils are on low lying ridges and hammocks in the Lower Coastal Plain. Slopes range from 0 to 2 percent. The regolith is a bed of unconsolidated loamy textured marine sediments influenced by fine calcareous materials. Near the type location, rainfall averages about 50 inches annually and the mean annual air temperature is about 73°F.

Bradenton soils are poorly drained. Runoff is slow. Permeability is moderate in the Bt horizon. The water table is at depths of less than 10 inches for 2 to 6 months annually during most years.

Most Bradenton soils are used for range. With adequate water control, some areas are used for citrus fruits, winter truck crops and improved pasture. Natural vegetation consists of slash pine, laurel and live oaks, cabbage, palm, southern bayberry, sweetbay, magnolia, American holly, bluestems, longleaf uniola, and panicum. A soil profile description for this soil is provided in Appendix E.

Bradenton-Bluff-Felda Association, Frequently Flooded. This association consists of poorly and very poorly drained soils in regular and repeating patterns along streams and rivers subject to flooding. Slopes are less than 2 percent.

Cassia Fine Sand. Cassia soils occur in landscapes in the Lower Coastal Plain on positions slightly higher than the adjacent flatwoods. Gradients are 0 to 2 percent, but some areas of the soil have gradients ranging to 5 percent. The regolith is a thick deposit of sandy materials. Near the type location annual precipitation averages about 55 inches and mean annual air temperature is about 73°F.

Cassia soils are somewhat poorly drained. Runoff is slow. Permeability is rapid in the A horizons and moderate to moderately rapid in the Bh. The water table is at depths of 15 to 40 inches for about 6 months duration during most years. During the driest season the water table drops to depths below 40 inches.

Most of the areas are in native vegetation consisting of scattered slash, longleaf pine and saw palmettos. Primary use is for range. A soil profile description for this soil is provided in Appendix E.

Delray Mucky Fine Sand, Depressional. Delray soils are on low broad flats or depressions in the lower coastal plain. Slopes range from 0 to 2 percent. They formed in sandy and loamy marine sediments influenced by limey materials. Near the type location mean annual precipitation is 49 inches and mean temperature is about 73°F.

These soils are very poorly drained; have slow runoff; rapid permeability in the A horizon and moderate to moderately rapid in the Bt horizon. The water table is at depths of less than 10 inches 6 to 9 months in most years and above the surface for 2 to 6 months in many years.

Much of the soil is cleared where water control is adequate. The soil is used for growing improved pasture, cabbage, tomatoes, sweet corn and string beans. Natural vegetation is southern bayberry, pickerelweed, sedges, reeds, water tolerant grasses and widely spaced cypress bay and tupelo trees. A soil profile description for this soil is presented in Appendix E.

Felda Fine Sand, Frequently Flooded. Felda soils are in depressions, poorly defined drainageways or low flat areas. Slopes are less than 2 percent. The soils formed in stratified unconsolidated marine sands and clays. At the type location, average annual precipitation is 48 inches and the average annual temperature is 73°F.

These soils are poorly drained with slow runoff and moderately rapid permeability. The water table is within 10 inches of the surface for 2 to 6 months each year. Depressions are flooded for more than 6 months each year.

A large part of the Felda soils has been cleared and where water control is adequate, it is used for growing fruits, truck crops and improved pastures. Natural vegetation is scattered cypress, myrtle, pond and slash pines, cabbage palmetto, pineland three-awn and many grasses, vines and shrubs. A soil profile description for this soil is provided in Appendix E.

Felda Variant Fine Sand, Cobbly Subsoil, 0-5 Percent Slopes. This soil consists of poorly drained and gently sloping soils. The surface layer is black fine sand about 6 inches thick. The subsurface layer is gray fine sand in the upper 7 inches, dark grayish brown, cobbly fine sand in the middle 6 inches and brown cobbly fine sand in the lower 19 inches. The subsoil is light brownish gray loam about 42 inches thick.

Floridana Mucky Fine Sand, Depressional. Floridana soils are in depressions and on low broad flats in the Lower Coastal Plain. Slopes are less than 2 percent. The regolith is a thick bed of sandy and loamy marine sediments. Near the type location, the average annual precipitation is about 55 inches and mean annual air temperature is about 74°F.

These soils are very poorly drained. Runoff is very slow to ponded. Permeability is slow to very slow. The water table is at depths of less than 10 inches below the surface and depressions are ponded for more than 6 months during most years.

Much of the soil on low broad flats is cleared and used for pasture. Where water control is adequate, the soil is used for growing cabbage, tomatoes, citrus and improved pasture. Natural vegetation consists of sand cordgrass, cabbage palmetto, myrtle and pineland three-awn. In depressions, most of the soil has a sparse to dense cover of cypress. A soil profile description for this soil is provided in Appendix E.

Hontoon Muck. Hontoon soils are in swamps and poorly defined drainageways. Slope gradients are less than 2 percent. They have formed in moderately thick beds of hydrophytic non-woody plant remains. Rainfall is about 55 inches annually; mean annual air temperature is about 74°F near the type location.

Hontoon soils are very poorly drained. Runoff is very slow. Permeability is rapid. The water table is at or above the surface of the soil except during extended dry periods. In drained areas, a water control system regulates the water table according to plant needs.

Most areas are in native vegetation and used for water storage and as wildlife habitat. Native vegetation is loblolly, bay maple, gum and scattered cypress trees with a ground cover of greenbriers, ferns and other aquatic plants. In a few areas there are slash pines with a ground cover of osmunda fern. A soil profile description for this soil is provided in Appendix E.

Immokalee Fine Sand. Immokalee soils are on the Lower Coastal Plain. Slope gradients are usually 0 to 2 percent, but adjacent to swamps, ponds, marshes and lakes, slopes range from 2 to 5 percent. The regolith is marine sands. Near the type location, annual precipitation is about 48 inches and mean annual air temperature is about 73°F.

These soils are poorly drained. Runoff is slow. Permeability is rapid in the A horizon and moderate in the Bh horizon. The water table is at depths of less than 10 inches for each 2 months duration in most years; it is within depths of 10 to 40 inches for periods of more than 8 months each year. It is at depths of more than 40 inches during dry periods. Depressions are covered with standing water for periods of 6 to 9 months or more in most years.

Principal vegetation is longleaf and slash pines and undergrowth of saw palmetto, gallberry, wax myrtle, and pineland three-awn. Most areas are used for range and forest. Large areas with adequate water management are used for citrus, improved pasture and truck crops. A soil profile description for this soil is provided in Appendix E.

Jonathan Fine Sand. This soil is a deep, moderately well drained soil formed in marine sediments and occurs on slightly elevated knolls and ridges in flatwoods areas. Slopes range from 0 to 2 percent. The surface layer is dark gray sand about 5 inches thick. The subsurface is light gray for about 38 inches. This soil comprises less than 15 acres in the mine site area.

Myakka Fine Sand. Myakka soils are poorly drained. They have slow internal drainage and slow runoff. Permeability is rapid in the A horizon and moderate or moderately rapid in the Bh horizon. The water table is at depths of less than 10 inches for 1 to 4 months duration in most years and recedes to depths of more than 40 inches during very dry seasons. Depressions are covered with standing water for periods of 6 to 9 months or more in most years.

Most areas are used for forest and range. Large areas with adequate water management are used for citrus, improved pasture and truck crops. Native vegetation consists of longleaf and slash pines with an undergrowth of saw palmetto, runner oak, gallberry, wax myrtle, huckleberry, pineland three-awn and scattered fetterbushes.

Myakka soils occur on nearly level areas with gradients of 0 to 2 percent. The soil formed in marine deposits of sandy materials. Near the type location rainfall averages about 50 inches annually with mean annual air temperature of more than 73°F. A soil profile description for this soil is provided in Appendix E.

Ona Loamy Fine Sand. Ona soils are in coastal flatwoods areas. Slopes range from 0 to 2 percent. The regolith is sandy marine sediments. Average annual precipitation is 55 inches and average annual air temperature is 73°F or more near the type location.

These soils are poorly drained. Permeability of the Bh horizon is moderate. Runoff is slow and internal drainage is impeded by the water table. The water table is at depths of 10 to 40 inches for periods of 4 to 6 months during most years. It rises to depths of less than 0 inches for periods of 1 to 2 months and may recede to depths of more than 40 inches during very dry seasons.

Much of the soil is used for growing truck crops, citrus and improved pasture. Natural vegetation is slash pine and longleaf pine, gallberry, widely spaced palmettos, huckleberry and pineland three-awn. A small part remains in forest and range. A soil profile description for this soil is provided in Appendix E.

Placid Fine Sand, Depressional. Placid soils occur in depressed areas or in low, nearly level, poorly defined drainageways on the lower Coastal Plain. Slope gradients are less than 2 percent. The soil has formed under conditions of fluctuating but very shallow ground water tables in thick beds of marine sand. At the type location, rainfall averages 50 inches annually and average annual temperature is about 73°F.

These soils are very poorly drained with slow runoff and rapid permeability, but internal drainage is impeded by a very shallow water table. Depth to the ground water table is 0 to 10 inches for more than 6 months in most years. In depressed areas the water table is above the soil surface for more than 6 months.

Placid soils are used mainly for range and forest. With water control a small acreage is used for truck crops, citrus fruits and improved pasture. Natural vegetation consists of pond pine, bay, cypress, gum, pickerelweed, and coarse grasses. A soil profile description for this soil is provided in Appendix E.

Pomona Fine Sand. The Pomona soils are on low, broad, nearly level ridges within the flatwoods areas of the lower coastal plain. Slope gradients are 0 to 2 percent. The soil formed in thick beds of sandy and loamy marine sediments. Near the type location, average annual precipitation is about 59 inches and mean annual air temperature is about 72°F.

Pomona soils are poorly drained. Runoff is slow. Permeability is rapid in the A horizon, moderate in the Bh horizon, and moderately slow in the Btg horizon. The water table is within depths of 10 inches for 1 to 3 months and is at depths of 10 to 40 inches for 6 months or more during most years. Depressions are covered with standing water for 6 to 9 months or more in most years.

A few small areas of the soil are cleared and used for watermelons, truck crops and improved pasture. Most of the areas remain in native vegetation consisting of slash, long-leaf and south Florida slash pine with an understory of saw palmetto, wax myrtle, gallberry, creeping bluestem, chalky bluestem, Indian grass and pineland three-awn. A soil profile description for this soil is provided in Appendix E.

Pompano Fine Sand, Frequently Flooded. Pompano soils are in poorly defined drainageways, broad, low flat areas and in depressions. Gradients range from 0 to 2 percent. These soils have formed in thick beds or marine sands. Near the type location, average annual precipitation is about 50 inches with a mean annual temperature of about 73°F.

Pompano soils are poorly drained. Runoff is slow. Permeability is very rapid, but internal drainage is impeded by a very shallow water table. The water table is at depths of less than 10 inches for 2 to 6 months each year. Even during the drier months it is within depths of 30 inches for more than 9 months each year. In depressed areas the water table is above the soil surface for more than 3 months each year.

Most of this soil is used for rangeland. With adequate water control, it is used for growing truck crops, citrus fruits and improved pasture. Natural vegetation is palmetto, widely spaced cypress, gum and slash pine and native grasses. A soil profile description for this soil is provided in Appendix E.

Pomello Fine Sand. Pomello soils are on the lower Coastal Plain. Slope gradients are mostly from 0 to 5 percent. The soil formed in marine sands. At the type location mean annual precipitation is 55 inches and mean annual temperature is more than 72°F.

These soils are moderately well drained with slow runoff and moderately rapid permeability. The water table is at depths of 24 to 40 inches for periods of about 1 to 4 months during the normal wet seasons. During the drier seasons of about 8 months duration, the water table ranges from about 40 to 60 inches.

Most areas are used for range and forest. Vegetation is scrub and dwarf live oaks, saw palmetto, longleaf and slash pines and pineland three-awn. A few areas are cleared and used mainly for improved pasture. A soil profile description for this soil is provided in Appendix E.

St. Lucie Fine Sand. St. Lucie soils are on nearly level to strongly sloping dune-like ridges and on isolated knolls. Slopes range from 0 to 12 percent. The soil formed in marine or eolian sand. Average annual precipitation ranges from 50 to 70 inches and the mean annual air temperature is more than 72°F at the type location.

These soils are excessively drained. Internal drainage and permeability are very rapid, but there is little or no surface runoff. Depth to the seasonal water table is 72 to 120 inches.

Some of the soil is used for building sites and as a source of sand for concrete, but most of it is in scrub forest. Vegetation is mainly sand live oak and sand pine, dwarf willow and some saw palmetto, rosemary, prickly pear cactus and lichens. A soil profile for this soil is presented in Appendix E.

Samsula Muck. Samsula soils are in swamps and poorly defined drainageways. Slope gradients are less than 2 percent. They have formed in moderately thick beds of hydrophytic non-woody plant remains. Rainfall is about 55 inches annually; mean annual air temperature is about 74°F.

Samsula soils are very poorly drained. Runoff is very slow. Permeability is rapid. The water table is at or above the surface of the soil except during extended dry periods. In drained areas, a water control system regulates the water table according to plant needs.

Most areas are in native vegetation and used for water storage and as wildlife habitat. Native vegetation is loblolly bay with scattered cypress, maple, gum and pine trees with a ground cover of greenbriars, ferns and other aquatic plants. A soil profile description for this soil is provided in Appendix E.

Smyrna Fine Sand. Smyrna soils are on nearly level flatwoods areas with slope gradients of less than 2 percent. They formed in thick deposits of marine sandy materials. Near the type location, rainfall averages about 55 inches annually; annual air temperature is about 74°F.

These soils are poorly drained. They have slow internal drainage and slow runoff. Permeability of the A horizon is rapid and the Bh horizon moderate or moderately rapid. The water table is at depths of less than 10 inches for 1 to 4 months duration in most years and between 10 and 40 inches for more than 6 months. In rainy seasons the water table rises above the surface briefly. In depressions, water stands above the surface for 6 to 9 months or more in most years.

Native vegetation consists of longleaf and slash pines with an undergrowth of saw palmetto, runner oak, gallberry, wax myrtle and pineland three-awn. Most areas are used for forest and range. Large areas are used for improved pasture. A soil profile description for this soil is provided in Appendix E.

Zolfo Fine Sand. The Zolfo series is on nearly level, low broad landscapes that are slightly higher than the adjacent flatwoods of the lower Coastal Plain in Central Florida. Slopes are 0 to 2 percent. Near the type location mean annual precipitation is about 55 inches and mean annual temperature is about 130°.

Zolfo soils are somewhat poorly drained. Runoff is slow. Permeability is very rapid in the A horizons and moderate in the Bh horizons. A water table is at a depth of 24 to 40 inches for 2 to 6 months during most years. It is at depths of 10 to 24 inches for periods of up to two weeks in some years. It is within depths of 60 inches for more than 9 months in most years.

This soil is used mainly for growing citrus crops. Native vegetation consists of scattered turkey, laurel or water oaks; longleaf or slash pine with an undercover of pineland three-awn, blue-stems, lop-sided Indiangrass, inkberry, native weeds and saw palmetto. A soil profile description for this soil is provided in Appendix E.

SOIL USES

Approximately 40 percent of the mine site soils are used for citrus production. The major soils used for citrus production are Immokalee, Ona, Tavares, and Zolfo. Less extensive citrus production also occurs on Bradenton, Felda, Placid, Pomona, and Sparr soils. These soils are all fine sands with rapid permeability in the surface horizons. Drainage is restricted, however, because of relatively shallow water tables (10 to 40 inches) for some part of the year. Most of the soils are frequently flooded in depressed areas and require drainage measures to produce citrus. The depth of these soils ranges from 60 to 100 inches.

Forty percent of the mine site is used for improved or semi-improved pasture. The soils used primarily for improved pasture are Floridana, Immokalee, Ona, Smyrna, and Sparr. Small acreages of the remaining soils in the project area are used for improved pasture. Like the citrus soils, pasture soils are sandy, poorly drained, deep, with relatively shallow water tables, and frequently flooded. These soils require drainage control for improved pasture production.

Approximately 10 percent of the area is presently occupied by pine flatwoods-palmetto rangeland. The soils of this land include Basinger, Bradenton, Immokalee, Placid, Pomano, Pomello, and Smyrna. These soils are sandy, deep with poor drainge, and relatively shallow fluctuating water tables. Flooding of these soils normally occurs for part of the year, limiting these soils to rangeland use when no drainage measures are implemented.

The remaining 10 percent of the area consists of wetlands and forested uplands. The soils comprising these areas are Bluff, Cassia, Hontoon, Samsula, and St. Lucie. They are very poorly drained and/or swampy, except for the St. Lucie soils which occur on knolls and dune-like ridges and are excessively drained. All wetland and forested upland soils have limitations which restrict agronomic use. Their primary value is for wildlife habitat.

4.2 ENVIRONMENTAL CONSEQUENCES OF THE ALTERNATIVES

The proposed mining and processing of phosphate rock at the Farmland site and subsequent reclamation of disturbed land will result in adverse impacts on the existing geology and soils environment. This section identifies the impacts associated with the alternative methods of accomplishing the identified project goals. The discussion is arranged by project component so that the alternative methods for any given component can be examined to an equal degree, thus providing a basis for comparison of alternatives. The first alternative discussed under each project component is Farmland's proposed action (Section 2.0). Only those project components relating to geology and soils are considered in this section. The last discussion within the section considers the geology and soils impacts of the no action alternative as it applies to the project as a whole.

4.2.1 MINING

Dragline Mining (Farmland's Proposed Action)

Site Disturbance. Dragline mining requires that woody vegetation be removed from the areas to be mined in advance of the actual mining operation. This will disturb surface soils and may result in increased soil erosion. While mining is to proceed at a rate of about 250 acres per year, Farmland indicates that the average advance clearing in front of the mining operation will be about 20 acres. The resultant impact (beyond that of actual mining) should be small.

Dragline mining will disturb the surface soils, entire overburden section, and the upper portion of the Hawthorn Formation containing the phosphate matrix over 4951 acres of the 7810-acre Farmland site. The total depth of disturbance will average about 41 feet, with a maximum of about 75 feet. Soils in the areas to be mined will undergo major disturbance and loss of identification.

Effects on Solutioning Activity. There will be no increase in solutioning activity resulting from mining activities, as the water table will not be lowered below the limestone units. Therefore, no collapse features resulting from the planned activities on local conditions are anticipated.

Solution cavities are known to exist in the Ocala Group which lies at a depth of 400 feet or more in this area. Due to the great depth to these units, no collapse features should result from loading, construction or other near surface activities.

Dredge Mining

As with dragline mining, dredge mining would result in the disturbance of surface soils in advance of the mining operation, and total disturbance of the entire overburden section during mining. The premining disturbance may be greater than that for dragline mining because of the dredge's materials handling limitations (e.g., stumps, etc.).

Bucketwheel Mining

The impacts of bucketwheel mining on geology and soils would be essentially the same as those of dragline mining, described above.

4.2.2 WASTE SAND AND CLAY DISPOSAL

Sand-Clay Mixing (Farmland's Proposed Action)

Most of the waste sand and clay generated by the processing of matrix will be disposed of through sand-clay mixing. These materials will also be stored separately where sand-clay mixing is not feasible, so that portions of the site will also have surfaces covered by these separate waste products. The area to be occupied by sand-clay mix, 3628 acres; clay, 583 acres; and sand, 104 acres. The locations of the various disposal areas are shown in Figure 2-41.

Selected physical and chemical properties of sand, clay, and sand-clay mix materials from the Farmland site were determined by Zellars-Williams, Inc. (1978). Farmland site soil samples were also collected. Sand-clay mixtures that covered the expected ratios to be used in Farmland's mining operation (1.9:1 to 3.1:1) were also prepared for analysis by Bromwell Engineering, Inc., of Lakeland, Florida. These mixtures had sand:clay ratios of 0.8 and 4.6 (on a weight basis). Laboratory analyses performed on each of the materials described above included: calcium, magnesium, phosphorus, potassium, and Radium-226 content; pH; and particle size distribution. Particle size and chemical data, including radio-chemical data, are presented in Tables 4-2 and 4-3, respectively. The physical and chemical characteristics of the various waste materials are discussed in the following paragraphs.

Sand-Clay Mixture. The two sand-clay mixtures tested would be classified as either a sandy clay loam or a loamy sand. Data in Table 4-3 show that tailing sand, one component of the sand-clay mix, is 100 percent sand. The other component, phosphatic clay, contains approximately 20 percent sand, 33 percent silt, and 47 percent clay-sized particles.

The chemical characteristics of the sand-clay mixes (Table 4-2) are also agriculturally superior to those of the natural pre-mining soils. Amounts of phosphorus, potassium, calcium, and magnesium generally range from 10 to 100 times greater in the mixes. The higher levels of these plant nutrients are in the range of normally productive soils, and would not require the addition of fertilizers containing these particular nutrients. The increased pH values of the mixes indicate that the application of lime (formerly required on the pre-mining soils for economical agricultural production) will not be required for the sand-clay mix. Applications of nitrogen fertilizer will be required on the mixes in order to maximize agricultural production, which is also true for the existing soils. Increased nitrogen use efficiency on the sand-clay mixes is anticipated because of reduced leaching rates and adsorptive properties of the clay.

Considerably more radioactivity is associated with the sand-clay mixes than with the natural pre-mining soil. The data suggests that the phosphatic clay contributes more than the tailing sand. These levels of Radium-226 are within the range projected for similar mining developments.

Clay. The undesirable agricultural characteristics of waste clay include poor tilth, delayed seed bed preparation, and cool soil temperatures. Such clays also present limitations with regard to future development (i.e., poor foundation material).

The chemical characteristics of clay waste as evaluated from the laboratory data obtained are as favorable, or more so, than the sand-clay mixes, and much superior (agriculturally) to those of the pre-mining soils.

Sand. The most undesirable agricultural characteristics of waste sand is its inability to retain water. For this reason it is not suitable as a seed bed or root zone material. Because of these limitations, Farmland proposes to cap sand disposal areas with a 2-foot layer of overburden (see next section).

Chemical analyses of waste sand indicate that, with the exception of potassium, it contains higher nutrient levels than existing surface soils.

Conventional Sand and Clay Disposal

Disposal of waste sand and clay as conventionally practiced in the Florida phosphate industry would increase the extent of the site to be covered with diked clay wastes from about 60 acres (using sand-clay mixing) to about 2500 acres. Such areas would have limitations similar to those described above for the separate clay disposal area under Sand-Clay Mixing. The larger dikes, etc. used for conventional clay disposal would also be of greater height than those for sand-clay mix areas and could be more susceptible to erosion.

4.2.3 RECLAMATION

Farmland's Proposed Reclamation Plan

The physical characteristics of the sand-clay mixtures to be used in reclamation will be agriculturally superior to those of the natural pre-mining soils. The larger proportion of clay and other larger size particles in the sand-clay mix will greatly increase the water holding capacity in the vegetation root zone and, to some degree, alleviate the droughtiness associated with the pre-mining soils. This added water holding capacity will also reduce the rapid leaching of soluble plant nutrients. The improved soil structure will also likely result in increased organic matter accumulation over a period of years.

Areas of separately stored clays will have more limited value because of their undesirable agricultural characteristics. With proper drainage, however, they should at least be suitable for pasture. The stability problems associated with such areas are an additional major concern.

Areas of separately stored sands will be capped with a 2-foot layer of overburden. Particle size data presented in Table 4-3 indicate that the overburden consists of strata in which particle size ranges from a sand to a sandy clay loam. These soil textures encompass the range of those previously discussed for the sand-clay mixes. All of the overburden textures represent a marked improvement for agricultural use relative to the pre-mining soil. Chemical analyses of overburden (Table 4-2) indicates differences in nutrient concentration between the strata. The calcium, magnesium, and potassium content of overburden to the 100-foot depth were found to be lower than for natural native range soil. Conversely, overburden values were much higher than natural improved pasture soil. In most cases overburden from strata deeper than 10-foot was found to be of higher nutrient content than the pre-mining soils. However, the relatively lower pH values (e.g., 4.4-5.7) found for overburden samples suggest that liming will be necessary for optimum growth of many crops.

Conventional Reclamation Plan

Reclamation as conventionally practiced in the Florida phosphate industry would increase the area of the site covered with soils of limited agricultural value (i.e., clays). Under Farmland's proposed plan, the extent of such areas would be about 600 acres. Using conventional methods, this area would increase to about 2500 acres.

The land areas of the site reclaimed with material other than waste clays would likely be graded overburden. The surface soils of such areas would be quite variable, depending on which strata became the new surface (see discussion of overburden cap for waste sand disposal area). Such areas would likely be suitable for use as improved pasture.

Conventional reclamation would also result in the creation of more extensive lakes than Farmland's proposed plan. This would reduce the land surface available for agricultural usage.

Natural Mine Cut Reclamation

Natural mine cut reclamation differs from both Farmland's proposed reclamation plan and conventional reclamation in that the overburden windrows created by the mining operation would not be graded and reclaimed as pasture. The landscape would be very irregular, resulting in soil erosion. Revegetation would also occur, eventually stabilizing most areas. The productivity of such soils would be limited to wildlife habitat. Natural mine cut reclamation in combination with sand-clay mixing would produce the smallest overall land acreage suitable for agricultural use (about 600 acres of settled clays). Conventional sand and clay disposal combined with natural mine cut reclamation would result in the creation of much larger areas of such soils (about 2500 acres of settled clays).

4.3 REFERENCES

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Geologic age		Stratigraphic unit		Thickness (feet)	Lithology	Remarks and identifying criteria
Period	Epoch					
Quaternary and Tertiary	Holocene, Pleistocene, Pliocene, and Miocene	Surficial deposits	Upper sand unit	0-70	Sand, clayey, very fine to medium-grained, predominantly fine-grained; white to brown; trace of phosphate in lower part, minor thin beds of limestone and bluish gray clayey sand and clay.	
			Shell and sand unit	0-33	Sand and clayey sand, very fine to fine-grained, gray to green; minor to abundant shells, including large oyster and barnacle shells.	
			Phosphorite unit	0-40	Clayey sand and sandy clay, fine-grained, calcareous to noncalcareous; abundant phosphorite nodules up to pebble size, white to gray in upper part, amber or black in lower part; includes beds of clean phosphatic sand and sand and gravel.	
Tertiary	Miocene	Hawthorn Formation Tampa Limestone	Hawthorn Formation and limestone unit of Tampa Limestone, undivided	160-370	In upper part, predominantly marl, dolomite, and limestone; soft, chalky, fine-grained to sandy or pebbly; abundant brown or black phosphorite grains or pebbles; minor thin-bedded sand and clay. In lower part, predominantly limestone, massive or thick-bedded, hard, dense, cherty, fossiliferous, phosphatic, white to gray and brown; minor thin-bedded sand and clay. Where underlying sand and clay unit is absent, equivalent beds are limestone, predominantly sandy, fossiliferous, gray, cherty; in places marly, soft, pebbly.	Generally the uppermost limestone in the section, less clastic than underlying sand and clay unit of Tampa Limestone, phosphatic throughout. Shows highest radioactivity of the section on gamma-ray logs.
		Tampa Limestone	Sand and clay unit of Tampa Limestone	0-230	Sand, fine-coarse grained, clean to silty, limey, grayish green; and clay, silty, sandy, marly, gray to pale green, and hard, waxy, dark green to black, marly; minor limestone.	Less phosphatic than overlying beds, reflected in lower radioactivity on gamma log. Sand and clay unit grades westward to sandy limestone (limestone unit of Tampa Limestone).
	Oligocene	Suwannee Limestone		100-250	Limestone, nodular, granular, chalky, some fragmental, some oolitic, usually very fossiliferous, cream to white, occasionally some clear quartz grains.	Clean, nodular, nonphosphatic limestone contrasts to overlying phosphatic clastics. Very low radioactivity on gamma-ray log
	Eocene	Ocala Group[1]		260-400	Limestone, chalky, nodular, granular, fragmental, some oolitic, generally very fossiliferous, cream, white, some buff, occasional dolomite in lower part, sucrosic to dense and cherty, yellowish brown to dark-brown and gray.	Lepidocyclina sp. and / or Camerina fossils abundant. Lepidocyclina usually appears 20-40 feet above Camerina. Zone of low radio-activity occasionally marks the top on gamma-ray logs
		Avon Park Limestone		200-470	Limestone, chalky, nodular, oolitic, fragmental, intergranular anhydrite and gypsum, very fossiliferous, cream, white, and buff, commonly thin dolomite in middle part, dense to finely crystalline or sucrosic, yellow to grayish brown.	Distinctive fossil Dictyoconus cookei.
			Dolomite unit	Maximum at least 150	Dolomite: massive, dense to finely crystalline or sucrosic, some coarsely crystalline, pale-yellow and brown to dark-brown and gray, mottled.	Lithology contrasts to overlying limestones, dolomite has high resistivity and self potential on electric log, and commonly high gamma radiation on gamma-ray log

[1] Designated Ocala Limestone by the U. S. Geological Survey.

TABLE 4-1. GEOLOGIC FORMATIONS OF HARDEE COUNTY
(From Wilson, 1977)

Table 4-2. CHEMICAL DATA - NATURAL SOIL AND SOIL MATERIALS FOR RECLAMATION.[1]

							Overburden[4]					
	Soil 0-6 inches		Sand:Clay Mix[3]				2-5 feet		5-10 feet		10-20 feet	
	Native Range	Crops and Pasture[2]	0.8	4.6	Tailing Sand	Phosphatic Clay	Native Range	Improved Pasture	Native Range	Improved Pasture	Native Range	Improved Pasture
Calcium (Ca) lbs/acre	360	995	>20,011	>20,011	>3,999	>20,011	324	>1,948	264	>3,999	>3,999	>3,999
Magnesium (Mg) lbs/acre	66	78	7,889	6,849	112	7,890	12	142	11	681	95	1,602
Phosphorus (P) lbs/acre	8	30	>666	>666	>133	>666	>133	>133	>133	>133	>133	>133
Potassium (K) lbs/acre	40	30	403	203	17.0	901	4	18	5	30	24	340
pH	4.2	5.0	7.6	7.7	6.3	7.7	4.4	5.5	4.6	5.7	4.6	7.1
Ra-266 Picocuries per gram	>0.1	0.3[5]	4.1	3.3	2.4	6.1	-	-	6.2[6]	3.0[6]	32.3	5.6

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[1] Calculated or taken from Radiation and Agricultural Productivity Analysis of Reclaimed Soils for Farmland's Hardee County Mine, Zellars-Williams, Inc. June 1978.

[2] Averages for 2 crops and 2 types of pasture. Radium 226 for improved pasture only.

[3] Tailing sand and phosphatic clay from beneficiation.

[4] Approximate depths.

[5] True value may be ± 50% because of less than optimum sample size.

[6] From 0.5 to 10 feet depth.

Table 4-3. PARTICLE SIZE DISTRIBUTION - NATURAL SOIL AND SOIL MATERIALS FOR RECLAMATION.

	Surface Soils[1] (0-6")	Sand:Clay Mix		Tailing Sand	Phosphatic Clay	Overburden[2]		
		0.8	4.6			2-5 feet	5-10 feet	10-20 feet
% Sand	96.4	63.8	83.8	100	19.8	89.7	82.9	58.0
% Silt	1.7	14.5	7.0	0	32.7	2.1	1.2	4.5
% Clay and Colloidal Organic Matter	1.9	21.7	9.2	0	47.5	8.2	15.9	37.5

[1] Averages for 8 range, pasture and cropped soils.
[2] Averages for 3 samples.

Source: Zellars-Williams, Inc. (1978).

5.0
RADIATION

5.1 THE AFFECTED ENVIRONMENT

5.1.1 REGIONAL DESCRIPTION

Naturally-occurring radionuclides such as uranium, thorium, and their decay products, as well as tritium, carbon-14, and potassium-40, are ubiquitous in nature and are usually fairly evenly distributed. However, some geological strata, such as marine phosphorite deposits, contain significantly elevated concentrations of uranium, thorium, and their decay products. In the United States, the phosphate deposits of Florida contain concentrations of uranium and its decay products at levels about 30-60 times greater than those found in average soil and rock. The presence of this radioactive material in extensive land areas in central Florida creates the potential for radiation exposure of the general population living on or near this land. The naturally-occurring background levels can be both significant and highly variable. The mining and processing of phosphate ore redistributes the radioactive material in the biosphere, thus offering some potential for altering the existing radiological environment by releasing some of these materials as gases, airborne particulates, or water-borne effluents. The following discussion will describe the natural radiation environment at the project site.

Radionuclides in Phosphate Deposits

The world's primary phosphate occurrences are of sedimentary origin and contain radioactive materials, predominantly uranium and its decay products. Uranium, along with a very small amount of thorium, is thought to have been deposited at the same time as the phosphate. The phosphate deposits of central Florida contain average uranium concentrations of about 100-150 ppm (EPA 1978). The uranium is usually in equilibrium with its radioactive decay products, at least through radium-226 (Guimond and Windham 1975).

Radioactivity is also present in parts of the overburden, specifically the "leach zone". This zone, also called the aluminum phosphate zone, is a discontinuous zone of altered friable phosphatic sandstone above the matrix varying in thickness from 1 to 10 feet. It is composed of quartz sand cemented and indurated by the secondary minerals such as wavellite, crandallite, and (locally) millisite. Also occurring is a fine-grained secondary cement composed of kaolinite and aluminum phosphate minerals. If a "leach zone" exists above the ore, it usually contains uranium in concentrations comparable to that of the matrix. Other portions of the overburden may also contain elevated radioactivity as compared to surface soils. The radioactivity is generally associated with the phosphate itself, since the uranium replaces the normal calcium in apatite. Consequently, the marketable ore and slimes containing most of the phosphate also contain most of the associated radioactivity. Two-thirds of the phosphate originally contained in the matrix remains in the marketable rock, with the remainder primarily in the slimes.

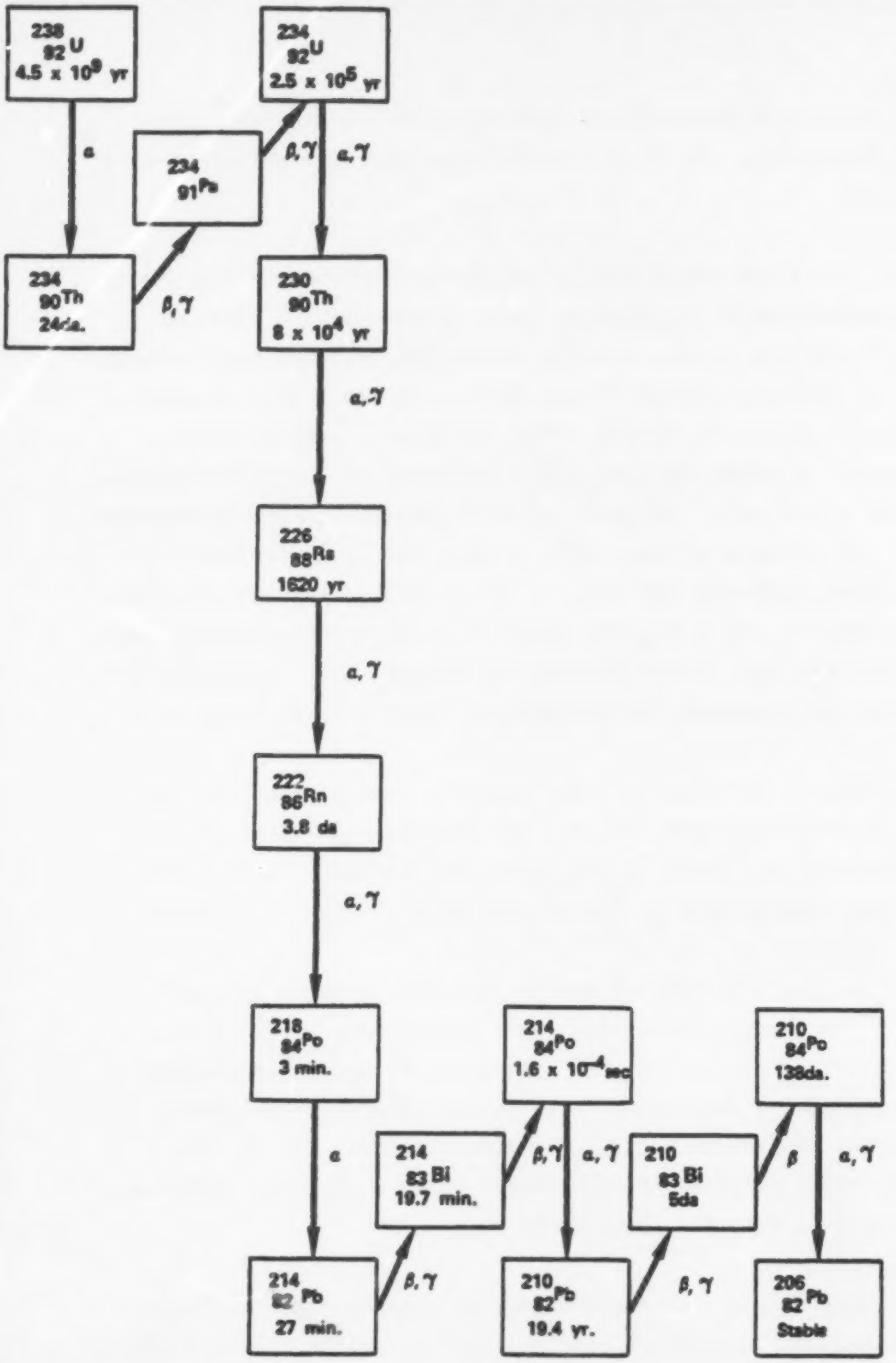
Soil throughout the United States typically contains between 0.2 and 3 picocuries (pCi) of radium-226 per gram. One would anticipate that normal Florida soils would contain this concentration range of radium-226 in areas that have been undisturbed by mining. However, anomalies may occur in areas where surface waters have exposed phosphate deposits or where such deposits are very close to the surface. Measurements indicate that the latter situation occurs in several areas in central Florida.

Unmined, reclaimed and disturbed phosphate land can contain widely varying concentrations of radium-226, as a function of the relative thickness and presence of low activity overburden soil and sand tailings as compared to higher activity matrix, slimes, or leach zone material. The presence of radium-226 and its decay products in soil presents a potential source of gamma exposure-gamma radiation to individuals living or working above the soil. However, of much greater concern is exposure arising from the release of radon-222, a noble gas decay product of radium-226 with a 3.85-day half-life. It may diffuse through the soil into the atmosphere, where observed radon-222 concentrations in the air are highly variable due to the influence of factors such as precipitation, barometric pressure, and atmospheric thermal stability.

The Uranium Series. In order to understand the hazard posed by disturbing the location and both the physical and chemical state of the natural radioactivity present in the phosphate matrix, a clear understanding of the complexities of the uranium decay series is required.

Uranium has two naturally occurring isotopes, uranium-238 and uranium-235. The uranium-238 series has a longer half-life and at present accounts for 99.3 percent of the naturally occurring uranium. Thorium-232 represents the parent radionuclide of another naturally occurring series, however, the concentration of thorium in Florida formations is small compared to uranium and does not present sufficient hazard potential to warrant consideration.

Uranium Equilibrium. In the uranium-238 series, decay proceeds through 13 intermediate daughter radionuclides until the stable nuclide, Pb-206, is reached. The nuclides in the series are diagrammed in Figure 5-1.



238 92 U 4.5 x 10^9 yr
α
234 91 Pa
β, γ
234 90 Th 24da.
β, γ
234 92 U 2.5 x 10^5 yr
α, γ
230 90 Th 8 x 10^4 yr
α, γ
226 88 Ra 1620 yr
α, γ
222 86 Rn 3.8 da
α, γ
218 84 Po 3 min.
α
214 82 Pb 27 min.
β, γ
214 83 Bi 19.7 min.
β, γ
214 84 Po 1.6 x 10^-4 sec
α, γ
210 82 Pb 19.4 yr.
β, γ
210 83 Bi 5da
β
210 84 Po 138da.
α, γ
206 82 Pb Stable

FIGURE 5-1. URANIUM-238 DECAY SERIES.

SOURCE: BOLCH (1979).

The nature of the series is such that a condition of equilibrium is achieved if the entire series is contained in a "sealed" location over a long period of time. In other words, a geological sample containing 100 pCi of U-238 may also contain 100 pCi of Th-234, 100 pCi of Pa-234, 100 pCi of U-234, and so on, through 100 pCi of Po-210.

Equilibrium is maintained only if the materials are undisturbed. Natural phenomena may produce a disturbance. A notable possibility is the potential transport of the noble gas radon-222 away from the location of its radium-226 parent.

Differential dissolution of specific materials by ground waters would also disturb the equilibrium; however, since uranium and radium are normally present in rocks and soil at equilibrium activity levels, the solubility of each of them and the intermediates must all be extremely low.

As they occur naturally, the radionuclides present in the phosphate matrix and leached zone have presented virtually no problem. The soil overlying the layers is normally sufficient to reduce gamma radiation exposure at the ground surface to background levels.

Radon-222 transport out of the matrix to the surface is also minimal. Radium-226 has evidently remained within the matrix for geologic ages in equilibrium with uranium-238 and has not contaminated the shallow and deep aquifers with any chemically significant amounts.

Mining, however, produces a considerable disturbance of this natural condition, leading to new transport pathways that must be addressed. Mining may cause the higher activity leached zone material and small quantities of the matrix to be redeposited near the ground surface upon reclamation. The physical character of the material containing the activity is changed as a new geohydrology is established.

The by-product materials from the processing of the phosphate matrix contain various amounts of uranium and its daughters.

In some cases, mined land is reclaimed with by-product materials from the processing of the phosphate matrix. These materials contain approximately one-third of the uranium originally present in the matrix. Physical processing does not appreciably alter the equilibrium from uranium-238 through radium-226. The impact of this redistribution of radioactive materials is addressed in Section 5.2.

Radon Progeny. The uranium-238 decay scheme equilibrium is highly dependent upon the mobility of radon-222, an inert gas. In the natural state, most of the radon-222 produced in a phosphate matrix would not escape the media. Mining and beneficiation not only alter the location and chemical condition of the radium-226 but may increase the probability that radon-222 will be able to diffuse from the site at which it was created. The rate of movement through the soil-air interface will be in units of pCi/m^2 sec and is termed "radon flux".

The airborne radon-222, whether in the open air, near industrial sources, or inside homes, will decay and an approach to equilibrium between the next four daughters (polonium-218, lead-214, bismuth-214, and polonium-214) will start. These four radionuclides are known as the radon progeny. Airborne radon and radon progeny concentrations are customarily expressed in Working Level (WL)* units.

Uranium-238, uranium-234, thorium-230, radium-226, and polonium-210 are all long lived radionuclides that could become airborne in dusty operations or by other mechanisms. The most critical industry operations with regard to these radionuclides are elemental phosphorus production and rock dryers. Neither operation is associated with the proposed facility.

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*Radiation standards for exposure to Rn-222 and its short-lived daughters are expressed in terms of working level (WL) concentrations. One WL is the amount of any combination of short-lived radioactive daughters of Rn-222 in 1 liter of air that will release 1.3×10^5 MeV of alpha energy during their decay to Pb-210.

Background Radiation

External gamma radiation levels in Florida approximate 7 to 10 microroentgens per hour, whereas the levels in the area of the Bone Valley phosphate deposits approximate 13 microroentgens per hour. Variations within the central Florida phosphate region are common, depending largely on depth of deposits. Overall, external whole-body gamma radiation exposure levels for Floridians are essentially equal to those reported for the average U.S. citizen, i.e., approximately 100 millirems per year. Additional variations in external gamma radiation levels are associated with materials used for construction (primarily roadways) and varied histories of land use (primarily phosphate mining and reclamation), although nearly all are within the range of the background.

Air. Exposures from air principally result from radon-222 gas (and its particulate daughter products) originating from the decay of radium-226 in soils. Average airborne radon-222 levels have been reported to be higher in Bartow than in Orlando or Jacksonville, Florida (Williams, et al. 1965). Lung dosage from radon-222 is 0.240 rads per year in the Bone Valley area compared with 0.130 in the remainder of the state. According to the Florida Department of Health and Rehabilitative Services (1978), the mean annual natural background WL concentration for the area is 0.004 compared with an inferred U.S. average of 0.001. Additional exposure is possible due to dust generated by the drying of phosphate rock and by chemical processing.

Water. In water the principal contaminant is radium-226 (Kaufmann and Bliss 1977). Lower Floridan Aquifer water samples from nonmineralized areas in central Florida exhibit a mean value of 1.4 picocuries per liter (pCi/l), and those for the Upper Floridan Aquifer are 5.1 pCi/l.

In mineralized but unmined areas, the respective values are 2.0 and 2.3, respectively, with the water-table waters containing 0.17 pCi/l. In mineralized and mined areas, the values are 1.96, 1.61, and 0.55, respectively.

Structures. Radioactivity concentrations in homes and other structures built on reclaimed land have been shown to be higher than in structures located on land outside the mineralized, phosphate area. According to the Florida Department of Health and Rehabilitative Services (1978), the average annual excess exposure to daughters of radon-222 (i.e., average above natural background) for persons living on enhanced [reclaimed] land within the central Florida phosphate region is calculated to be 540 millirems per year to the whole lung. They found that: (1) radiation levels on undisturbed non-mineralized land do not approach or exceed the National Council on Radiation Protection and Measurement (NCRP) Maximum Dose Recommendations; (2) radiation levels in structures on undisturbed mineralized land approach and in some cases exceed those guidelines; and (3) radiation levels in structures built on reclaimed lands approach and in some cases exceed the guidelines.

Workers. Radiation exposures to phosphate employees working under normal procedures and conditions have been found to be well within the guidelines for occupational exposures and generally within the guidelines for the general population. Elevated levels of radiation were found only in the vicinity of acidulation tanks and phosphoric acid filters, piping, and filtrate tanks--and these areas are not routinely occupied by workers. Radon progeny levels have been found to be high in rock-loading tunnels, but this can be controlled by proper ventilation. Specific exposures to workers are highly variable depending on the absolute localized radioactivity concentrations, the number of hours that the workers spend at the various locales, and the distance to the various concentration levels. Gross alpha radioactivity in vegetables grown in the Bone Valley phosphate region is higher than in vegetables grown outside the region, and gross beta radioactivity is slightly higher (EPA 1978). Representative radium-226 concentrations are given in Table 5-1 for various portions of the environment in the central Florida phosphate region.

Subsurface Radioactivity

Since the origin of the uranium in the deposits is similar to the phosphate, the concentration of uranium should follow the concentrations of phosphate: a low concentration in the overburden and a high concentration in the matrix. The actual distribution is slightly different. In both the north Florida and west central Florida mining regions, the radioactivity is low at the surface, increases gradually and then more rapidly with depth and is most concentrated in or just above the matrix. Uranium and radium are in general equilibrium. If present, the leached zone is usually marked by high radioactivity.

Surface Water Radioactivity

Radium-226 in surface waters of the U.S.A. is generally low (between 0.01 and 0.1 pCi/l) except for certain locations such as mineral springs, waters with high solids content, and waters that drain fertilized farming areas.

Groundwater Radioactivity

The potential of groundwater contamination with radium-226 or other contaminants due to phosphate mining operations is a concern. The most extensive review of the literature and data analysis for west central Florida have been undertaken by Kaufmann and Bliss (1977). They statistically analyzed available radium data from 1966 and from 1973-1976 in three strata: upper water table, Upper Floridan Aquifer, and Lower Floridan Aquifer. Each water resource was considered in three geographic areas of west central Florida: mined (mineralized) areas, unmined mineralized areas, and nonmineralized areas. The basic data summary is shown in Table 5-2.

5.1.2 SITE STUDIES

Background Radiation

Direct radiation monitoring on the Farmland property was begun in November 1977. The results of 12 months of monitoring at nine stations are summarized in Table 5-3. With the exception of Station 7, direct radiation levels over the Farmland property are relatively constant at about 3.6 millirads per month, or roughly 43 millirads per year. Station 7 is located in the southern section of the property along Oak Creek. The depth of the overburden at this point is 5 feet or less (Farmland 1979). The high direct radiation levels at Station 7 are due to the limited radioactivity shielding provided by the thinner overburden. The average monthly direct radiation levels for all stations remained relatively constant through February, when a modest drop occurred which continued through April. This occurrence has been noted during other radiological monitoring studies conducted in May and June 1977 and January 1978. The drop in direct radiation levels which typically occurs during the spring and summer months is theorized to be due to the decreased washout of gamma-emitting radon daughters to the ground surface as a result of lower rainfall during this period.

Subsurface Radioactivity

Radiation levels and agricultural productivity of reclaimed soils have become important considerations in developing reclamation plans for proposed mining developments. In order to address these considerations for its Hardee County property, Farmland contracted with Zellars-Williams, Inc. to undertake a study of the radiological and agronomic properties of material expected to comprise the surface soils on the site after reclamation. Surface soil possibilities for such mining developments include the following:

- overburden spoil material
- clay waste

- tailing sand waste
- various mixtures of clay and sand wastes

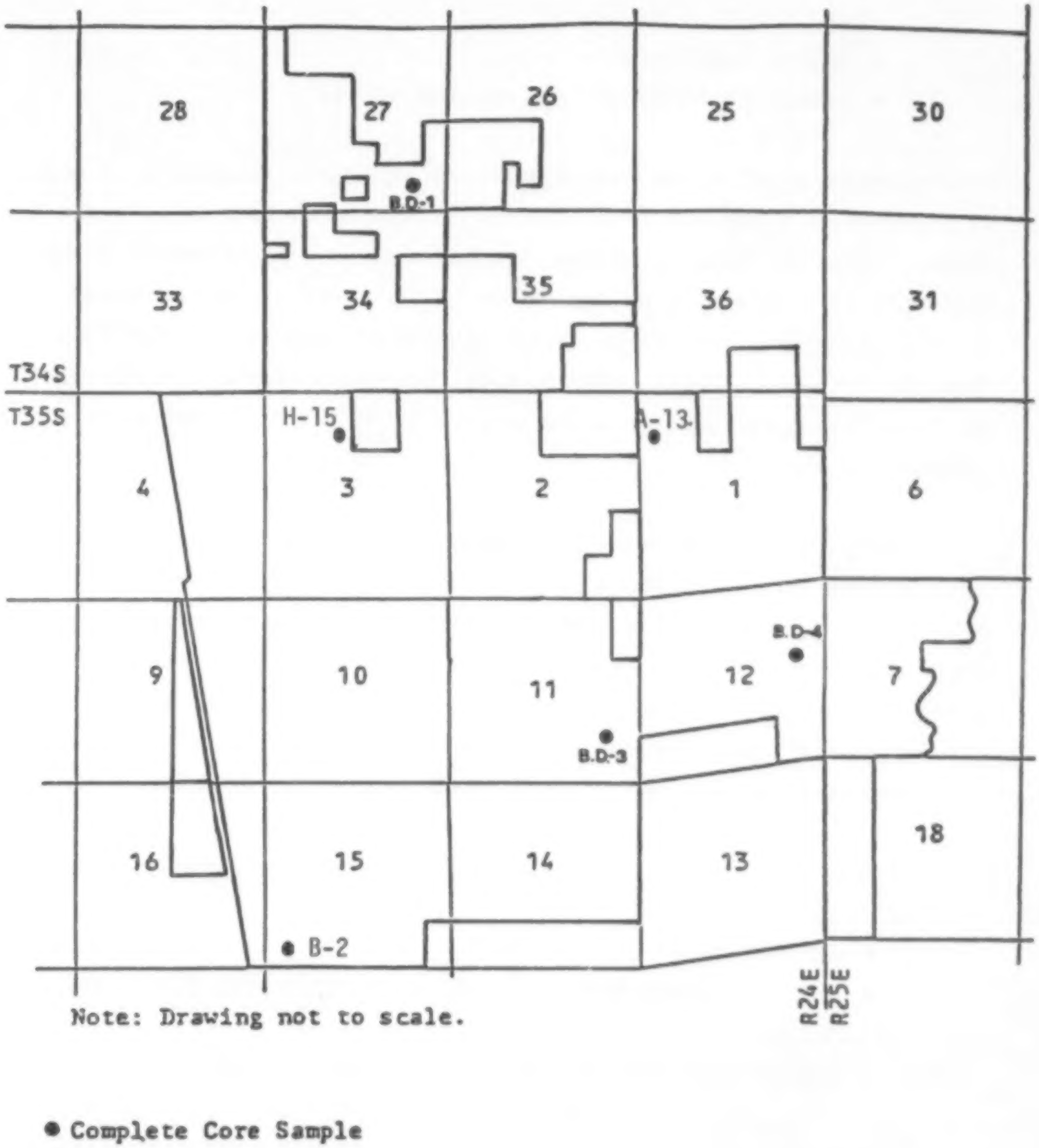
Generalizations as to the radiological and agronomic properties of each of these soils types can be made based on past experience in existing mines. However, these properties are known to vary considerably within each soil type depending on the unique constituency of the materials. It was, therefore, decided to obtain samples of each of the materials from the Farmland site in order to make reasonably accurate predictions of the radiological and agronomic properties of the reclaimed soils expected on the site.

Samples were collected using standard core drilling equipment. Core samples were taken at three locations shown in Figure 5-2 (B.D.-1, B.D.-3, and B.D.-4). Using previous test drilling as a guide, these three sites were selected by Zellars-Williams, Inc. geologists as most nearly representative of the ore body as a whole. Previous test drilling analysis did not consider overburden properties other than depth. The overburden sampling may be considered as a random sampling.

In each drill hole, the following samples were collected:

- top soil (0-0.5')
- composite overburden (0.5'-10' or junction with leach zone or matrix)
- composite overburden (10' to leach zone if present)
- leach zone (if present)
- matrix (potentially mineable matrix was divided into splits in the field)

A Zellars-Williams, Inc. geologist was present during core sampling to identify the various strata. Since unmineable low-grade phosphate ore overlying the mineable matrix must be excavated and spoiled to expose


28
27
26
25
30
B.D-1
33
34
35
36
31
T34S
T35S
H-15
A-13
4
3
2
1
6
9
10
11
12
7
B.D-4
B.D-3
16
15
14
13
18
B-2
R24E
R25E

Note: Drawing not to scale.

● Complete Core Sample

FIGURE 5-2. SAMPLING LOCATIONS FOR FARMLAND INDUSTRIES, INC. RADIATION AND AGRICULTURAL SOILS STUDY.

SOURCE: ZELLARS-WILLIAMS, INC. (1978)

the matrix, such material was considered as overburden. Matrix splits were washed in a Zellars-Williams, Inc. washer. Pebble, feed, and slime fractions were separated and saved for analysis. The feed was floated to produce concentrate product and sand tailings using 60 pound charge batch flotation equipment.

Mineability of matrix splits was determined on the basis of BPL, acid insoluble, and MgO analysis of the matrix and its components. Samples of tailing sand and slime from mineable splits were sent to Bromwell Engineering for preparation of sand-clay mix samples. Tailing sand and slime from mineable splits for all three drill holes were composited and composite sand and clay used to prepare three ratios of sand-clay mixture--0.8, 4.6, and 10.1. Samples of top soil, composite overburden, leach zone (if present), matrix and matrix components for each of the drill holes were sent to Environmental Science and Engineering (ESE) for radium-226 analysis. Bromwell Engineering sent samples of composite clay, composite sand, and the three sand-clay mixtures to ESE for radium-226 analysis.

Radium-226 analyses for the components of each of the core samples are given in Table 5-4. For comparison purposes, radium-226 concentrations reported for various soil materials in the central Florida mining area are listed in Table 5-5. Top soil samples for all three drill holes on the Farmland site exhibited low radium-226 contents within the range commonly observed for surface soil samples in central Florida. Composite overburden samples exhibited somewhat higher radium-226 contents. In most cases radium-226 contents for overburden samples were within the range expected for overburden samples. However, two of the overburden samples--the 10- to 20-foot composite in B.D.-1 and the 0.5- to 10-foot composite in B.D.-3--had unusually high radium-226 concentrations of 32.3 and 21.4 picocuries per gram (pCi/g), respectively. In fact, the radium-226 levels for these two overburden samples are over three times the levels for their corresponding matrix samples.

These unusually high values are difficult to explain. No visibly distinct leach zone was identified for these two drill holes. Radium-226 and uranium contents are generally positively correlated with phosphate content. BPL analysis for these two overburden samples yielded values of 9.2 percent and 14.4 percent for the B.D.-1 and B.D.-3 holes, respectively. The observed BPL values, therefore, do not correlate with the observed radium-226 contents.

It is possible that the observed radium levels represent local concentrations occurring in association with aluminum phosphates. If so, these overburden strata fit the criteria generally used to define a leach zone (see page 5-2) and perhaps should have been designated as such despite the fact that they did not meet visual criteria for leach zones. Certain evidence supports this explanation. In each case, these strata overlie the phosphate matrix, although in B.D.-3 the upper matrix layer was considered by the geologist present to be unmineable. In addition, the observed radium-226 contents for the two strata are within the range commonly observed for leach zone strata. On the other hand, there is the possibility that an analytical error is responsible for these unusually high values.

Matrix samples exhibited lower radium-226 contents than average reported matrix samples. The observed values are, however, within the rather wide range commonly observed for matrix samples in central Florida. As is typical of matrix samples, the pebble and concentrate components displayed the highest levels, tailing sand the lowest levels, and slime intermediate levels. All the observed tailing sand contents are within the reported range. As indicated in Table 5-5, previously reported radium-226 contents for slimes vary widely. In a radiation analysis similar to this study conducted for a proposed mining development in Manatee County, radium-226 contents for slimes were reported to vary from 3.2 to 5.6 pCi/g. Radium-226 levels in slimes have, however, been reported to be as high as 52 pCi/g. Except for the slimes fraction of the B.D.-1, the observed values for the Farmland samples are more in line with the Manatee County study. The radium-226 content of 12.2 pCi/g observed for the B.D.-1 slimes sample is within the reported range but appears to be inconsistent with the other two slimes samples.

Radium-226 levels for composite clay, composite tailing sand, and the three sand-clay mix ratios prepared by Bromwell Engineering are given in Table 5-6. As expected, the composite clay exhibits the highest levels while the composite sand exhibits the lowest levels. Sand-clay mixtures exhibit intermediate radium-226 levels which decrease as the sand-clay ratio increases.

Farmland requested ESE to reanalyze a number of splits from the three cores and to measure radium-226 on splits from three additional cores. The locations from which these additional cores were taken are also shown in Figure 5-2. In addition, WCC arranged for independent analyses for uranium-238, thorium-230, and radium-226 on portions of the same splits from two of the six cores. The Wilson Laboratories of Salina, Kansas performed these measurements. These additional analyses served three purposes. They substantially broadened the radiological data base on the Farmland property; they provided a specific quality control program for all analyses; and the Wilson Laboratories results provide an insight into the state of radioactive equilibrium in the splits. The results of all additional analyses are given in Table 5-7.

The doubtful results from the first set of cores were confirmed. Agreement among measurement on samples from the same splits was satisfactorily within sampling and analytical uncertainties. The results of the Wilson Laboratories analyses showed little disturbance of the radioactive equilibrium among uranium-238, thorium-230, and radium-226. Only the leach zone from core A-13 showed a significant depletion of uranium. These data confirm the assumption frequently used in the analysis of reclamation plans that these radionuclides are substantially in radioactive equilibrium.

Surface Water Radioactivity

A monthly surface water and sediment sampling program on the Farmland property from June 1977 to June 1979 collected a total of 162 samples for radioassay. Surface water samples were analyzed for gross alpha radioactivity in dissolved and suspended fractions and for total radium-226. Sediment samples were assayed for radium-226 content.

Dissolved gross alpha radioactivity results ranged from less than 0.4 to 24.0 pCi/l, while suspended gross alpha radioactivity concentrations ranged from less than 0.3 to 11.8 pCi/l. Since many of the gross radioactivity results were below the detection limits of the monitoring instrumentation, no average values were calculated (Farmland 1979).

Radium-226 results from the surface waters ranged from less than 0.1 to 4.4 pCi/l. Of the radium results above detection limits (144), the average value was 0.6 pCi/l. Radium-226 concentrations in stream sediments ranged from less than 0.1 to 58.8 pCi/g, with the average of the 155 measurable levels being 4.6 pCi/g (Farmland 1979).

Groundwater Radioactivity

An alpha monitoring program for ground waters on the project site was completed in June 1978. A total of 15 samples were collected from three Surficial Aquifer wells on a quarterly basis. Seven other groundwater samples were collected between July 1977 and July 1978 from the Secondary Artesian and the Floridan Aquifers. All 22 of the groundwater samples were assayed for dissolved and suspended fractions of gross alpha radioactivity and for radium-226 content.

Gross alpha radioactivity levels found in the suspended fractions of both the shallow and deep groundwater samples were found to be in the same range as those levels found in the surface water samples. These levels ranged from less than 0.2 to 8.6 pCi/l in the Surficial Aquifer samples, from less than 3.5 to 6.2 pCi/l in the Secondary Artesian

Aquifer samples, and from less than 1.0 to less than 3.1 pCi/l in the Floridan Aquifer. Dissolved gross radioactivity levels in ground waters were found to be considerably higher than those found in surface waters. Dissolved gross alpha radioactivity ranged from 4.3 to 115.4 pCi/l in Surficial Aquifer samples. Samples from the Secondary Artesian Aquifer had dissolved gross alpha radioactivity levels of from 9.3 to 12.1 pCi/l, while the Floridan Aquifer samples ranged from less than 1.0 to 4.5 pCi/l.

Radium-226 levels detected in the ground waters were found to be considerably higher than those found in surface waters. The Surficial Aquifer samples averaged 0.9 pCi/l (arithmetic mean) and ranged from 0.1 to 2.8 pCi/l. Radium-226 levels in the three Secondary Artesian Aquifer samples ranged from 13.9 to 16.0 pCi/l, and the four Floridan Aquifer samples ranged fro 1.5 to 6.7 pCi/l. All samples from the Secondary Artesian Aquifer exceed the EPA interim drinking water standard of 5 pCi/l for radium-226 (EPA 1976a).

The deep-well samples results are in agreement with other findings which have been published for this region. While the highest concentrations of gamma radioactivity occur in the leach zone, most of the total gamma radioactivity is found from 130 to 380 feet below the ground surface (P.E. LaMoreaux and Associates 1978). Gamma activity drops off to near background levels below 400 feet.

5.2 ENVIRONMENTAL CONSEQUENCES OF THE ALTERNATIVES

The proposed mining and processing of phosphate rock at the Farmland site and subsequent reclamation of disturbed land will result in adverse impacts on the existing radiation environment. A description of the impacts associated with the alternative methods of accomplishing the identified project goals is presented in this section. The discussion is arranged by project component so that the alternative methods for any given component can be examined to an equal degree, thus providing a basis for comparison of alternatives. The first alternative discussed under each component is Farmland's proposed action (Section 2.0). Only those components having impacts relating to Radiation are considered in this section. The last discussion within the section considers the radiation impacts of the no action alternative as it applies to the project as a whole.

5.2.1 MINING

Dragline Mining (Farmland's Proposed Action)

In the mining process, the overburden overlying the matrix is stripped away and deposited in an adjacent previously mined area as a series of spoil banks. As conventionally practiced, materials that were originally near surface would be placed at the bottom of the spoil pile, while the materials which were just above the matrix would be placed at the top of the pile. Core analyses have shown the radium-226 profile in the site overburden to range from less than 1 pCi/g near the surface to a high of about 67 pCi/g in the leach zone at the overburden-matrix interface. Thus, dragline mining (as conventionally practiced) would result in the exposure of the leach zone and its relatively high radioactivity (Figure 5-3) to the atmosphere. However, the direct radiological impacts to operating personnel near the mine should be minimal. Prince (1977) found the average external gamma radiation levels in the vicinity of draglines to be about 5 μR/hr (near baseline). Radon progeny levels were also found to be present at low levels (0.0004 WL concentrations). This is a lower value than has been found within slab-on-grade structures on unmined land in Polk and Alachua Counties, which ranged from 0.001 to 0.032 WL.

Dredge Mining

Dredge mining, like dragline mining, would disrupt the natural occurrence of radioactive materials within the overburden. However, the

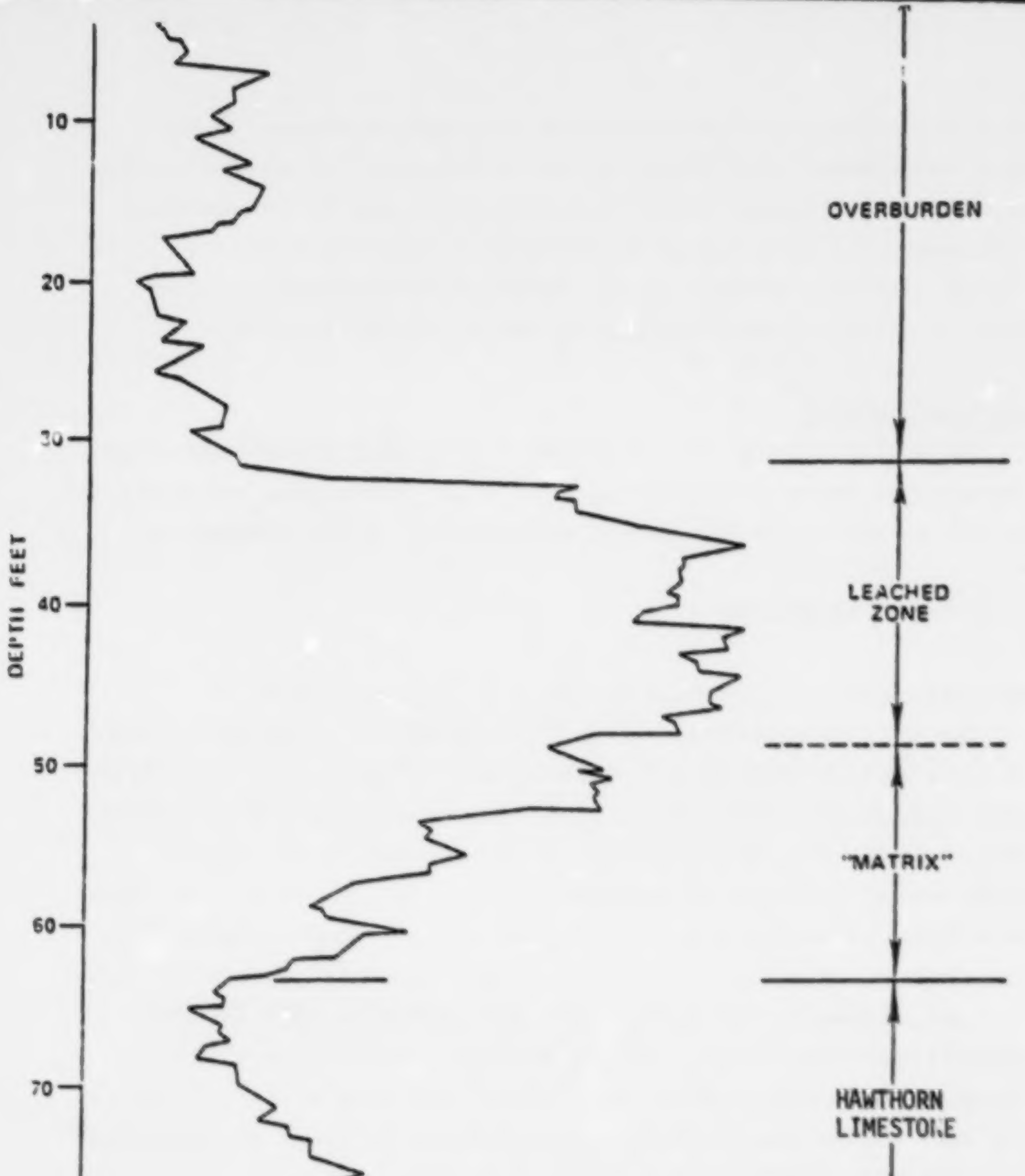


FIGURE 5-3. GAMMA-RAY LOG OF AN EXPLORATORY HOLE IN THE FLORIDA LAND PEBBLE PHOSPHATE DEPOSIT.

SOURCE: U.S. Geological Survey. (1979).

redistribution of such layers would be more uniform because of the mixing which would occur during slurry transport of the overburden from the mine to the disposal area. Since the water used to transport the overburden would be in direct contact with radioactive materials, it is possible that some increase in the levels of radioactivity in these waters would occur even after most of the solids had settled.

Bucketwheel Mining

Bucketwheel mining, like dragline mining, would disrupt the natural occurrence of radioactive materials within the overburden, and result in the same potential for exposure of such material to the atmosphere.

5.2.2 MATRIX PROCESSING

Conventional Matrix Processing (Farmland's Proposed Action)

The physical composition of the Farmland matrix is shown in Figure 5-3. The distributions of radioactivity within the matrix from selected existing mines (Roessler, et al. 1978) and for the Farmland site (Farmland 1979) are shown in Figure 5-4. From the washer plant come a coarse product (pebble), an intermediate-sized product (flotation feed), and a fine clay waste product. The clays in west central Florida have about the same concentration of radium-226 as the input matrix (both on a dry weight basis), the actual level being dependent upon the efficiency of the washer plant. In general, west central Florida clays average about 45 pCi/g radium-226. Pilot plant studies with the matrix from the Farmland site indicate that the concentration in the separated clays should be from 4.6 to 12.2 pCi/g radium-226.

Flotation feed is routed to the flotation plant where concentrate and a sandy, waste fraction (termed sand tailings) are produced. The tailings at this site represent about 60 percent (by weight) of the incoming matrix. After separation, they contain only a small fraction of the matrix radioactivity. Samples from operating west central

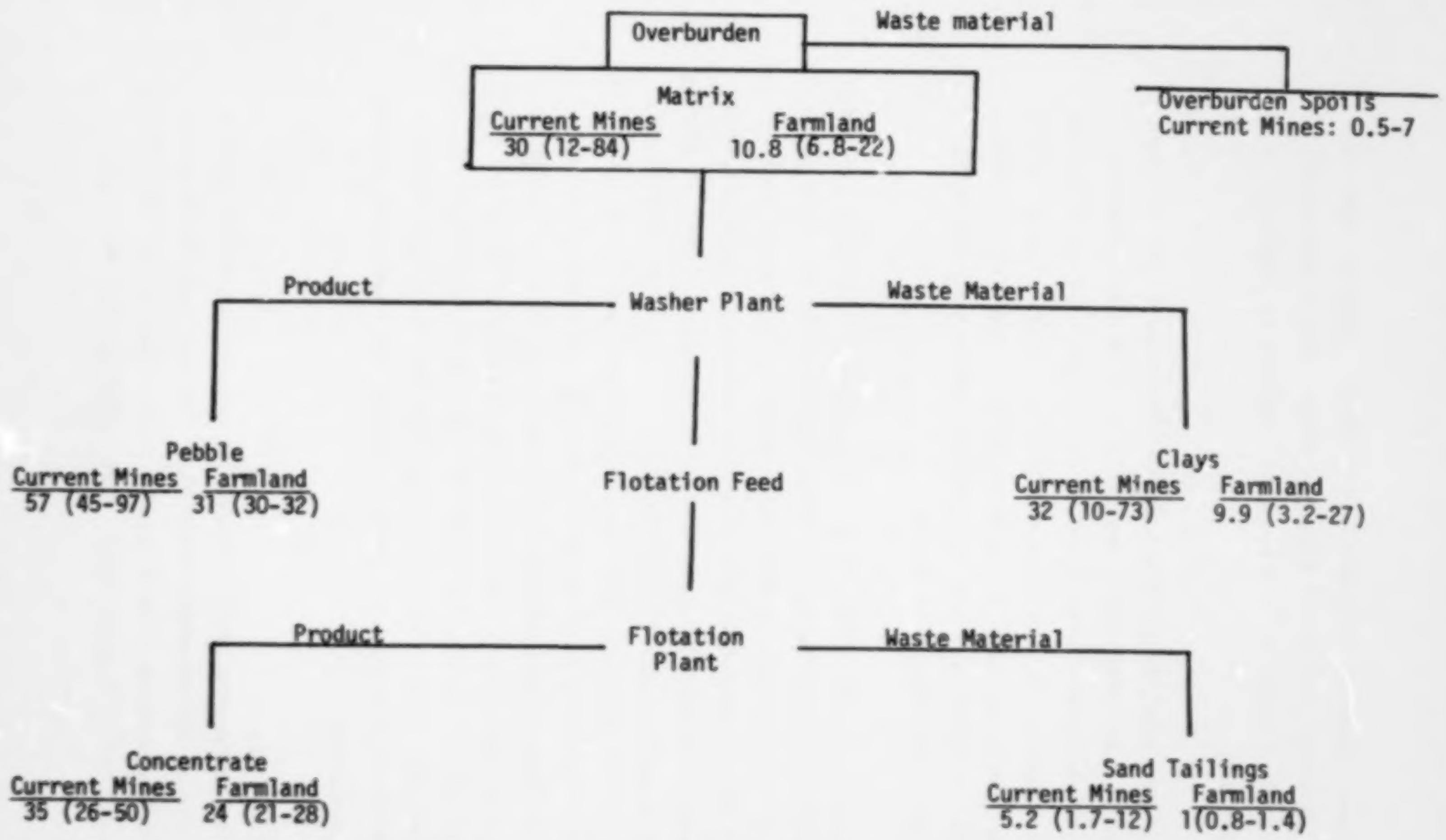

Overburden
Waste material
Matrix
Current Mines
30 (12-84)
Farmland
10.8 (6.8-22)
Overburden Spoils
Current Mines: 0.5-7
Product
Washer Plant
Waste Material
Pebble
Current Mines
57 (45-97)
Farmland
31 (30-32)
Flotation Feed
Clays
Current Mines
32 (10-73)
Farmland
9.9 (3.2-27)
Product
Flotation Plant
Waste Material
Concentrate
Current Mines
35 (26-50)
Farmland
24 (21-28)
Sand Tailings
Current Mines
5.2 (1.7-12)
Farmland
1(0.8-1.4)

FIGURE 5-4. COMPARISON OF RADIUM IN CURRENT CENTRAL FLORIDA PRODUCTS AND WASTES TO EXPECTED VALUES FOR THE FARMLAND INDUSTRIES, INC. PROJECT (Ra-226 in pCi/g).

SOURCES: Farmland Industries, Inc. 1979; Roessler, et al. 1978.

Florida mines were found to average about 5 pCi/g. Samples from the Farmland site indicate that these tailings should have a radium-226 concentration of 1 to 3 pCi/g, a value which appears to represent a very efficient separation.

Prince (1977) found the external gamma radiation levels in beneficiation plants to be about twice the background levels. However, results of a work-station survey found occupancy factors low enough to reduce annual exposures to insignificant levels. Radon progeny levels were below the levels reported for slab-on-grade structures on unmined land (0.0007 WL). Therefore, the radiological impacts to operating personnel at the plant should be minimal.

Prince (1977), in his study of the occupational radiation exposures in the phosphate industry, found wet rock storage piles to yield gamma radiation at an average rate of 67 μR/hr. However, occupancy factors around such piles are extremely small, making the annual exposure to an individual insignificant. In areas where the occupancy factor is high, the elevation in gamma radiation was found to be low. Wet rock storage and transfer tunnels (located under wet rock piles) were found to be the most serious radiological hazard areas. Working level measurements at eleven sites yielded levels between 0.0007 WL and 0.096 WL. While an occupational time-place study indicated a low occupancy factor for such tunnels, Prince (1977) recommends that all tunnels be mechanically ventilated; and that such areas be made limited access for personnel. With properly ventilated tunnels, workers should not experience adverse occupational exposures.

Dry Matrix Processing

Dry matrix processing would involve the separation of the matrix fractions by air or electrostatic methods. This dry separation would produce tremendous amounts of particulate matter, requiring the control of airborne radioactive particulates. Even with control measures, radioactivity in the area of the beneficiation plant would likely be higher than if conventional methods were used.

5.2.3 SAND AND CLAY WASTE DISPOSAL

Sand-Clay Mixing (Farmland's Proposed Action)

As indicated previously, the processing of matrix at the Farmland plant will produce two solid waste streams--clays and sand tailings. Both of these streams will contain radioactive materials. Analyses conducted by Farmland indicate that the radium-226 levels in the waste clays and sands from their plant will be on the order of 9.9 and 1.0 pCi/g, respectively (Figure 5-4). Both of these figures are significantly below values reported by Roessler, et al. (1978). The radium-226 concentrations which would result can be determined from Figure 5-5. For the proposed ratio of 2.5:1, the radium-226 concentration should be about 3.5 pCi/g. Farmland's reclamation plan calls for 80 percent of the reclaimed area to be filled with a sand-clay mixture. Another 8 percent will be reclaimed by covering sand tailings with 2 feet of overburden. The remaining 12 percent of the reclaimed land (583 acres) will be the final clay settling area. Areas covered with overburden should have an average radium-226 level of 2.5 pCi/g, but "spikes" are expected throughout because of the occurrence of matrix or high activity material (i.e., leach zone) originally just above the matrix. The tailings beneath the overburden should be more uniform, with radium-226 concentrations being about 2.4 pCi/g throughout. Separately impounded clays sediments are expected to yield an average concentration of 6.1 pCi/g, but with both higher and lower "spikes". A small amount of low activity overburden (~0.5 pCi/g) or topsoil is expected at the surface.

The redistribution of radioactivity in waste sand and clay will also alter the terrestrial gamma radiation where these materials are deposited. Table 5-8 illustrates the gamma radiation levels that have been measured over various land types as a result of mining in Polk County.

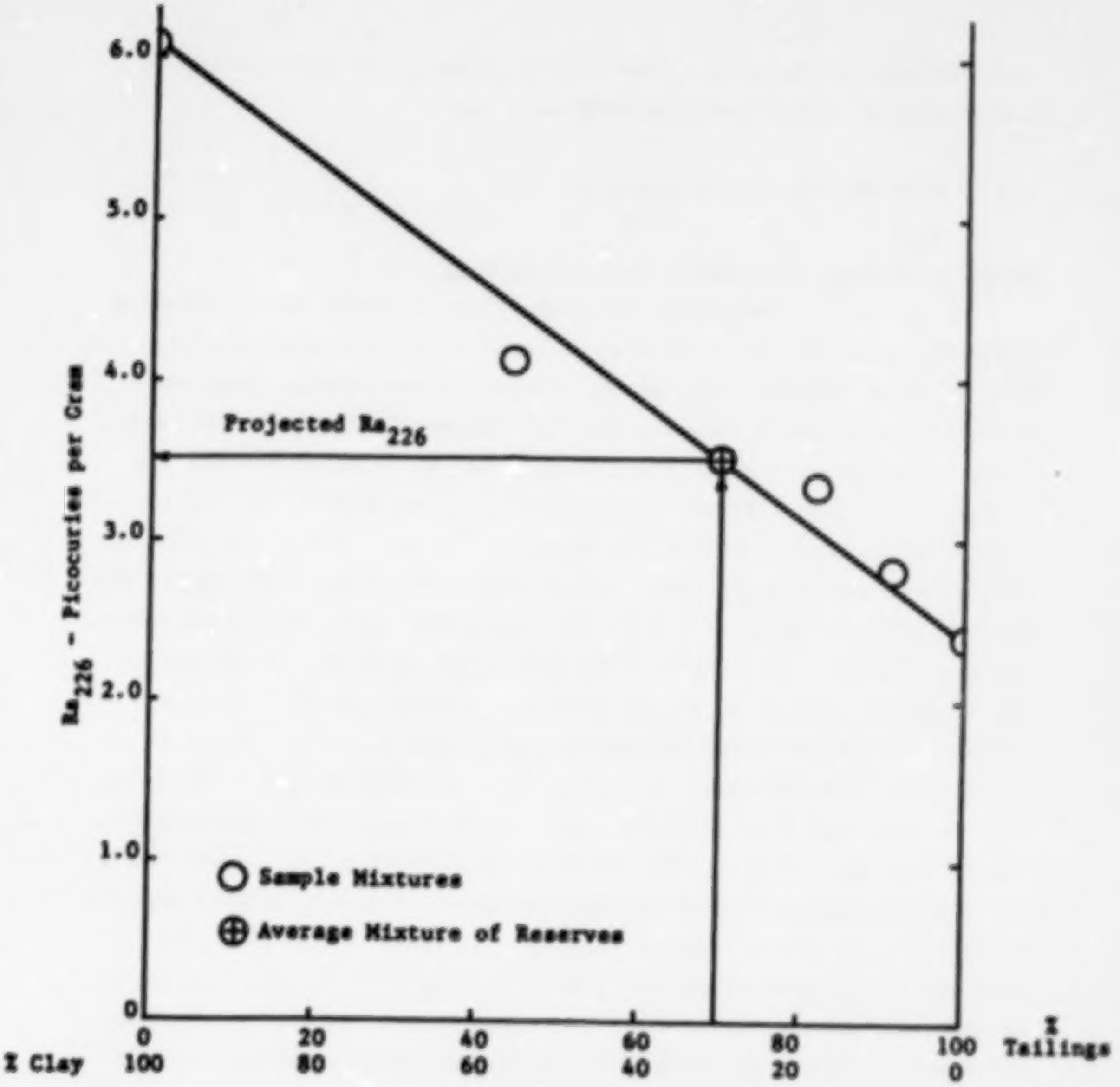


FIGURE 5-5. RADIUM-226 CONCENTRATIONS AT VARIOUS SAND-CLAY MIX PERCENTAGES.

SOURCE: FARMLAND INDUSTRIES, INC., DRI, JUNE 1979

Table 5-8 contains the predicted gamma radiation levels for sand and clay waste from the Farmland mine. These estimates consider the expected uranium, thorium, and potassium contents of various post-reclamation land types following Beck and dePlanque (1968), who give exposure rates in air for each ppm of uranium, thorium, and potassium in soils. The waste clay will emit the highest amount of gamma radiation (12.9 μR/hr @ 1m). However, only a small fraction of the site (12 percent) will be covered by this material, and its high water content may reduce the gamma level through shielding. The remainder of the waste products are expected to meet or only slightly exceed the 10 μR/hr interim recommendation for gamma exposure levels at new structure sites on Florida phosphate lands (EPA 1976b). If a low activity layer of soil or rock approximately 6 inches thick were placed on the surface, the soil component of the gamma radiation would be reduced by more than a factor of 2. All reclaimed lands would then satisfy the gamma exposure level criterion for new structure sites.

An additional concern about the waste materials is the amount of radon-222 flux from them. The level of radon flux is considered an indicator of the potential hazard of indoor radon progeny within slab-on-grade residential and public structures.

Table 5-9 summarizes predicted radon flux values for various waste surfaces. The first column lists the results of a mono-layer diffusion model (without topsoil) and the second column contains the values predicted by a bi-layer diffusion model (with topsoil). Specific parameters for each waste type were taken from the data of Roessler, et al. (1978) for similar media. For each land type, the reduction is between 20 and 30 percent. However, even the uncapped values are within the range of radon-222 fluxes which have been observed on unaltered lands (Table 5-10). Therefore, the increase in outdoor airborne radon-226 concentrations from these fluxes should be insignificant.

Conventional Sand and Clay Disposal

Conventional clay disposal would result in the separate disposal of sand and clay waste materials. This would create about 2500 surface areas with higher radiation levels (on the order of 6.1 pCi/g) than using sand-clay mix methods.

5.2.4 RECLAMATION

Farmland's Proposed Reclamation Plan

As indicated previously, the reclaimed mine site will have different radiological characteristics than the premined site. The resultant impact of this new radiological environment will depend upon the end land use of given areas and the levels of the various radiological characteristics. Of the many radiation exposure pathways that are possible, three appear to be most directly related to reclamation and land use: (1) WL elevation in residential structures; (2) the uptake of radionuclides into agricultural products; and (3) the impact of returning lands to natural systems.

Residential Development. Of the many land uses considered, the most critical appears to be residential development. This impact must be considered, whether for small numbers of homes in the immediate future or significant numbers in the distant future, for uranium-238 and radium-226 have geological scale half-lives.

Indoor radon and radon progeny concentrations as measured by WL have been related to increased risk of lung cancer (Fisher 1978). Since indoor WL measurements are not possible before construction, considerable research effort has gone into pre-construction predictor measurements and the associated correlations. Three parameters have been considered for prediction of indoor WL: external gamma exposure rate;

soil radium; and surface radon flux. The prediction equations given by Roessler, et al. (1978) are:

$$WL = 0.0022\ (G-3.6)^{1.01}$$

$$WL = 0.0065\ (C_{Ra})^{0.563}$$

$$WL = 0.0087\ (J)^{0.461}$$

where

G = external gamma exposure, μR/hr

C_{Ra} = soil radium-226, pCi/g

and

J = surface radon flux, pCi/m^{2}s.

Table 5-11 summarizes the predicted indoor WL by land type for the Farmland site after reclamation.

It is apparent that the clay area will represent the highest potential hazard. However, this material is one of the least attractive land types for home building because of foundation design problems. Furthermore, reclaimed clay areas only represent some 12 percent of the site. Slab-on-grade structures in Polk County over undisturbed lands have WLs ranging from 0.001 to 0.010, with a geometric mean of 0.003. Two standards for WL in existing homes have been proposed: (1) a 0.029 WL total exposure including background (Florida Department of Health and Rehabilitation Services 1978) and (2) a 0.020 WL total exposure including background (EPA 1979). The final rule-making by the State of Florida is expected in the near future. It is anticipated that the "gray" area between normal background and the aforementioned WL standard will be handled on a case-by-case basis with cost versus benefit considerations.

The reclamation processes and undeveloped lands were not addressed in detail in EPA's 1979 recommendations to the Governor of Florida (EPA 1979). Specific guidance for new homes on any reclaimed, debris, and unmined lands which contain phosphate resources integrated both site selection and construction technique:

> "IV. Development sites for new residences should be selected and prepared, and the residences so designed and sited, that the annual average indoor ...." Working Levels " ...do not exceed .... background levels...." (EPA 1979)

Normal background and its uncertainties are discussed in the same report. The EPA indicated that "guidance...to aid in evaluation of undeveloped phosphate lands" (EPA 1979) will be forthcoming and that the interim recommendations (EPA 1976b) are still appropriate.

If the final guidance for reclaimed lands is similar to the recommendation quoted above, then the upper limit of predicted WLs in slab-on-grade homes will be approximately 0.009 WL (normal background of 0.004 WL plus the uncertainty of 0.005 WL). Overall, the Farmland site, as reflected in Table 5-11, will slightly exceed this upper range. Note, however, that Table 5-11 was constructed without consideration of the return of any topsoil to the land categories. Either the addition of low activity topsoil to a potential development site or some restrictions in the type of housing construction should mitigate the WL hazard satisfactorily. Only the clay settling areas appear to have the potential for producing homes with greater than 0.02 WL.

Agricultural Uses and Uptake. Some 73 percent of the reclaimed site is expected to be improved pasture initially and a small percentage may be used for citrus and row crops.

The scientific literature contains little information on the potential for crop uptake of radium-226. Most literature data suffer from the lack of companion information on other nutrients in the soil and in the crops. Table 5-12 indicates the general level of radium-226 in some food products of the United States.

The return of any low activity topsoil to reclaimed areas would substantially reduce any potential impact. The most important pathway to consider is the direct uptake by row crops grown on the reclaimed clay. Here the radium-226 content is the highest and land will be suited for this productive use. Little is known about the behavior of radium-226 uptake from this type of soil. The results of a limited study were reported by Bolch (1979). Two squash crops were planted, one on reclaimed clays and one on undisturbed lands. Squash samples and the soil from each location were analyzed for radium-226 and available nutrient data were obtained (Table 5-13). For this set of samples, the higher activity soil produced the lower activity squash. Bolch suggests that this apparent abnormality is related to the order of magnitude greater concentration of Ca++ and Mg++ ions in the clay than in the undisturbed land. He suggests that the Ra++ ions (minute chemical quantities) are diluted and discriminated against by the other alkaline earth ions.

The small acreage involved, the lower radium-226 levels, and the expected land use distribution combine to suggest that the impact of any agricultural uptake pathway will be insignificant. Since current fertilizer products, such as TSP, may contain up to 32 pCi/g radium-226, the direct application of fertilizer products to crops may be much more important than direct uptake from the reclaimed soil being farmed.

Natural Systems. Farmland proposes to reclaim over 20 percent of the mine site in natural systems (e.g., forest, freshwater marsh, freshwater swamp, lakes). Uranium and radium-226 in the reclaimed soils are not expected to have any impact on the development of the natural ecosystems. In fact, the developing environments are expected to favor retention of the radioactive species.

Conventional Reclamation

Reclamation as conventionally practiced in the Florida phosphate industry would increase the area of the site with exposed soils having radium-226 concentrations on the order of 6.1 pCi/g. Under Farmland's proposed plan, the extent of such areas would be about 600 acres. Using conventional methods, this acreage would increase to about 2500 acres.

Natural Mine Cut Reclamation

Natural mine cut reclamation differs from both Farmland's proposed reclamation plan and conventional reclamation in that the overburden windrows created by the mining operation would not be graded and reclaimed as pasture. Because of the irregular topography created by natural mine cut reclamation, much of the site would not be suitable for residential or agricultural use. Thus, the pathways to the human environment would be eliminated. The areas used for disposal of waste clays could be utilized for pasture and would thus be a potential source of uptake. The natural systems that would develop over most of the site would also tend to retain radioactive species.

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Table 5-1. REPRESENTATIVE RADIUM-226 CONCENTRATIONS IN CENTRAL FLORIDA PHOSPHATE AREA ENVIRONMENT.

Item	Radium-226 Concentration
Background soil	1.5 pCi/g
Silt	1.1 pCi/g
Beach sand	0.9 pCi/g
Reclaimed soil	10-30 pCi/g
Overburden (excluding leach zone)	10 pCi/g
Leach zone materials	40 pCi/g
Matrix	40 pCi/g
	60 pCi/g
Wet phosphate rock	29-34 pCi/g
	42 pCi/g
Sand tailings	7.5 pCi/g
	6.2-8.8 pCi/g
Slime particles	45 pCi/g
	33-52 pCi/g
Slime decant water (dissolved fraction)	1-2 pCi/ℓ
Slime decant water (undissolved fraction)	33.5-52 pCi/g
Mine water	< 1.5 pCi/ℓ
Ground water	< 1.5 pCi/ℓ
Slime-pond water	< 2 pCi/ℓ
Leachate from gypsum pond	60-100 pCi/ℓ
Gypsum	21-33 pCi/ℓ
Phosphate products (undifferentiated)	42 pCi/g
Phosphoric acid plant effluent after double liming	1.8-4.5 pCi/ℓ
Slag from calcination processes	56 pCi/g
Water-table water (mineralized mined areas)	0.55 pCi/ℓ
Upper Floridan water (mineralized mined areas)	1.61 pCi/ℓ
Lower Floridan water (mineralized mined areas)	1.96 pCi/ℓ
Ammonium phosphates	5-6 pCi/g
Superphosphates	21 pCi/g
Phosphoric acid	< 1 pCi/ℓ
Animal feed supplements	5-6 pCi/g

Source: U.S. Environmental Protection Agency. 1978.

Table 5-2. SUMMARY OF RADIUM-226 DATA IN CENTRAL FLORIDA AQUIFERS

Area Description	Water Table		Aquifer			
			Upper Floridan		Lower Floridan	
	No.	pCi/l[1]	No.	pCi/l	No.	pCi/l
Unmined Mineralized	23	0.17	5	2.30	24	2.0
Mined Mineralized	12	0.55	10	1.61	6	1.96
Nonmineralized (Control)	No Data		3	5.1	14	1.4

[1] All data are geometric means of author's preferred data.

Source: Kaufmann and Bliss 1977.

Note: Drinking water standard for total radium is 5 pCi/l.

Table 5-3. SUMMARY OF DIRECT RADIATION LEVELS MEASURED ON THE FARMLAND INDUSTRIES PROPERTY NEAR ONA, FLORIDA: DECEMBER 1977 THROUGH NOVEMBER 1978

Average Dose Per Station		Monthly Average of All Stations	
Station Number	Average Dose (millirads)	Month	Average Dose (millirads)
1	3.9	December, 1977	4.9
2	3.7	January, 1978	5.0
3	3.3	February, 1978	5.2
4	3.9	March, 1978	4.5
5	3.4	April, 1978	4.2
6	3.4	May, 1978	4.8
7	14.1	June, 1978	4.8
8	3.3	July, 1978	4.3
9	3.5	August, 1978	4.2
		September, 1978	5.3
		October, 1978	4.1
		November, 1978	5.8

Source: Farmland Industries, Inc. 1979.

Table 5-4. RADIUM-226 ANALYSES OF CORE SAMPLES FROM FARMLAND INDUSTRIES, INC. HARDEE COUNTY PROPERTY.

Sample	Component	Radium-226 Content (Picocuries per gram)	BPL Content (%)
(B.D.-1)	Top Soil (0-0.5')	< 0.1	0.8
	Composite Overburden (0.5-10')	6.2	3.3
	Composite Overburden (10'-20')	32.3	9.2
	Matrix (20'-32')	9.7	19.4
	Pebble	32.3	29.4
	Concentrate	30.2	70.4
	Tailings	3.3	4.5
	Slimes	12.2	14.0
(B.D.-3)	Top Soil (0-0.5')	0.3	0.5
	Composite Overburden (0.5-10')	21.4	14.4
	Composite Overburden[1] (10'-26.5')	7.1	15.3
	Matrix (26.5'-47')	6.8	23.0
	Pebble	32.9	49.4
	Concentrate	23.8	66.3
	Tailings	0.7[2]	1.5
	Slimes	4.6	18.8
(B.D.-4)	Top Soil (0-0.5')	0.3[2]	1.1
	Composite Overburden (0.5'-6')	3.0	1.0
	Leach Zone (6'-10')	6.4	9.8
	Composite Overburden[1] (10'-15')	5.6	14.2
	Matrix (15'-36')	8.5	12.6
	Pebble	29.8	58.4
	Concentrate	26.0	67.9
	Tailings	3.2	4.2
	Slimes	5.0	13.4

[1] Overburden actually low grade matrix considered unmineable by geologist present.

[2] Due to the small quantity of sample submitted for analysis, these results could vary by 50 percent.

Source: Environmental Science and Engineering, Inc.

Table 5-5. REPORTED RADIUM-226 CONCENTRATIONS FOR VARIOUS SOIL MATERIAL IN THE CENTRAL FLORIDA MINING AREA

Material	Radium-226 Concentration (pCi/g)		Reference
	Average[1]	Range	
Surface Soil[2] (0-30 cm)	0.5	0.2-3.8	Roessler, Wethington and Bolch (1978)
Upper Layer Overburden (0-1.8 m)	0.6	0.2-3.8	Roessler, Wethington and Bolch (1978)
Overburden (0-top of Leach Zone)	1.6	0.2-7.2	Roessler, Wethington and Bolch (1978)
Leach Zone	9.4	1.2-45.6	Roessler, Wethington and Bolch (1978)
Overburden (0-Matrix)	2.5	0.2-30.6	Roessler, Wethington and Bolch (1978)
Matrix	25.9	6.0-136.5	Roessler, Wethington and Bolch (1978)
Tailing Sand	3.1	0.5-8.7	Roessler, Wethington and Bolch (1978)
Clay	4.2[3]	3.2-5.6	[4]
	-	33-52	Florida Dept. of Health and Rehabilitation Services (1975)

[1] Average = geometric mean.

[2] Surface soil samples taken from a depth of 0-30 cm. or roughly twice the sampling depth used for Farmland surface soil samples.

[3] Average = arithmetic mean.

[4] Results from confidential study for proposed mining development.

Table 5-6. RADIUM CONTENT OF COMPOSITE WASTES FOR FARMLAND RADIATION STUDY

Sample	Radium-226 Content (Picocuries per gram)
Composite Clay	6.1
Sand:Clay Ratio 0.8:1	4.1
Sand:Clay Ratio 4.6:1	3.3
Sand:Clay Ratio 10.1:1	2.8
Composite Sand	2.4

Source: Bromwell Engineering, Inc.

Table 5-7. RADIOMETRIC ANALYSES OF CORE SAMPLES FROM THE FARMLAND INDUSTRIES, INC. MINE PROPERTY.

Core Sample	Split	Depth	Description	Results of Analyses (pCi/g)			
						Radium-226	
				Uranium[1]	Thorium-230[1]	Analysis 1[1]	Analysis 2[2]
B.D.-1	1	0-5'	Loose sands	4.7	4.6 ± 1.6	2.0 ± 0.6	<0.2
	2	5-7.5'	Organic leach	1.0	1.1 ± 0.3	1.6 ± 0.5	2.0
	3	7.5-12'	Upper sandy clay	9	18 ± 3	16 ± 5	27.2
	4	12-20'	Soupy sand and leach	22	24 ± 4	22 ± 7	35.5
	5	20-25'	Matrix	11	18 ± 5	22 ± 7	13.4
H-15	1	0-10/5'	Loose sand and sandy clay				5.1
	2	10.5-46.5'	Upper soupy sand				11.4
	3	46.5-50'	Matrix				5.6
A-13	1	0-6'	Loose sand	0.17	0.39± 0.26	0.18± 0.05	0.7
	2	6-16'	Hardpan and sandy clay	3.1	7.5 ± 2.3	4.9 ± 1.5	7.7
	3	16-25'	Leach zone	33	90 ±40	67 ±20	70.2
	4	25-40'	Matrix	4.7	9.4 ± 3.5	6.1 ± 1.8	14.6
B-2	1	0-8'	Loose sand				91.0[3]
	2	8-14.5'	Tough sandy clay				55.3
	3	14.5-18.5'	Leach zone				3.2[3]
	4	18.5-21'	Upper tough clays				12.6
	5	21-27'	Matrix				9.8
B.D.-3	1	0-5'	Loose sand				0.8
	2	5-12.5'	Leached upper clays				25.5
	3	12.5-29.5'	First matrix to overburden				8.4
	4	29.5-45'	Matrix				8.1
B.D.-4	1	0-2'	Loose sands				0.3
	2	2-8.5'	Clayey composite overburden				3.9
	3	8.5-20'	Matrix				13.8

---

[1] Analyses done for Woodward-Clyde Consultants by Wilson Laboratories of Salina, Kansas.

[2] Analyses done for Farmland Industries, Inc. by Environmental Science & Engineering, Inc. of Gainesville, Florida.

[3] Radium-226 values appear to be off by an amount suggestive of mislabeling of these samples.

Table 5-8. GAMMA RADIATION CHARACTERISTICS OF RECLAIMED LAND ON THE FARMLAND SITE

Land Type	Predicted Gamma, μR/hr @ 1 m	Cosmic Contribution, μR/hr	Total μR/hr
Overburden Reclaimed	6.1	3.6	9.7
Sand/Clay Mixture	8.3	3.6	11.9
Tailings Reclaimed	5.7	3.6	9.3
Clay Reclaimed	12.9	3.6	16.5

Source: Adapted from Beck and dePlanque (1968).

Table 5-9. RADON FLUX PREDICTED FROM RECLAIMED LANDS ON THE FARMLAND SITE.

	Radon-222 Flux, pCi/m^{2}s	
Land Type	Without 2-ft of Topsoil	With 2-ft of Topsoil
Overburden Reclaimed	0.95	0.68
Sand/Clay Mixture	1.3	0.94
Tailings Reclaimed	0.91	0.66
Clay Sediments	2.3	1.7

Source: Adapted from Roessler, et al. (1978).

Table 5-10. SUMMARY OF RADON-222 FLUX CHARACTERISTICS OF VARIOUS LAND TYPES IN POLK COUNTY

Land Types	No. of Sites	Radon-222 Flux, pCi/m^2s Mean	Radon-222 Flux, pCi/m^2s Range
Unaltered	17	0.2	0.1-1.7
Unmined Radioactive Fill	2	1.3	0.6-2.8
Tailings	19	0.7	0.1-2.7
All Overburden	27	1.5	0.1-12.8
Capped and Mixed Clays	6	1.6	0.3-7.2
Uncapped clays	2	4.4	3.6-5.4
Debris	15	4.2	1.7-13.7

Source: Roessler et al. 1978.

Table 5-11. INDOOR RADON PROGENY BY LAND TYPE AS PREDICTED BY VARIOUS RADIOLOGICAL PARAMETERS

Land Type	Estimated WL Gamma, μR/hr vs WL	Estimated WL Ra-226, pCi/g vs WL	Estimated WL Radon-222 Flux pCi/m^2s vs. WL
Overburden Reclaimed	0.014	0.011	0.0083
Sand/Clay Mixture	0.019	0.013	0.0098
Tailings Reclaimed	0.013	0.011	0.0083
Clay Sediments	0.029	0.018	0.013

Note: All values without topsoil in order to present maximum hazard.

Table 5-12. RADIUM-226 IN SOME UNITED STATES FOOD PRODUCTS

Diet Item	Radium-226 pCi/g
Fresh Vegetables	0.0016
Root Vegetables	0.0012
Whole Grain Products	0.0027
Rice	0.0033
Eggs	0.0140

Source: Fiesenne and Keller. 1970.

Table 5-13. UPTAKE OF RADIUM-226 BY SQUASH ON CLAY RECLAIMED AND UNDISTURBED LANDS

	Radium-226 (pCi/g)		Available Nutrients (lbs/acre)	
Land Type	Squash	Soil	CaO	MgO
Undisturbed Soil	0.0072	0.17	600	100
Reclaimed Clay	0.0024	13.00	5600	2600

Source: Bolch. 1979.

6.0
GROUNDWATER

6.1 THE AFFECTED ENVIRONMENT

6.1.1 GROUNDWATER QUANTITY

The occurrence and availability of groundwater is determined by a cyclic exchange of water between the earth and the atmosphere known as the hydrologic cycle. Surface water accumulates from precipitation and from groundwater flow that intercepts the earth's surface. It may return to the atmosphere by evaporation and transpiration or it may seep into the earth and recharge groundwater supplies. Groundwater fills voids in permeable soil and rock units. Saturated units with relatively high permeabilities are known as aquifers. Most of the groundwater that is part of hydrologic cycle exchanges comes from aquifers that are connected to the surface by topographic lows, wells, faults or caverns. Less permeable units, called aquitards, and nearly impermeable units, called aquicludes, may also contain water but this water is not readily free to flow.

The fundamental principles governing the occurrence and movement of groundwater are given in reports by Meinzer (1923a, 1923b), and others.

Water seeping through the soil first enters a zone of aeration which lies between the land surface and the zone of saturation. A part of the water entering the zone of aeration satisfies soil-moisture requirements and is held in this zone by molecular forces which counteract the force of gravity. The rest seeps downward into the zone of saturation. The top of an unconfined saturated zone is called the water table, and its position is shown by the level at which water stands in water table wells. Unconfined water in the zone of saturation moves slowly down the gradient through the aquifer. Variations in the height of the water table occur as a result of factors such as the permeability and structure of the rocks, fluctuations in the rate of withdrawal of water from wells and springs, and fluctuations in rainfall which affects the rate of recharge.

Aquifers bounded above and below by relatively impermeable formations are called confined aquifers. These aquifers may be recharged by rainfall and runoff seepage where they outcrop on the land surface. Hydrostatic pressures within a confined aquifer may be sufficient to cause the water in any well penetrating the aquifer down-dip from the recharge area to rise above the bottom of the upper confining layer. This type of aquifer is called artesian. The height to which water rises in a well penetrating an artesian aquifer is called the potentiometric surface.

If the confining layers are aquicludes, leakage may occur into or out of a confined aquifer. The direction of leakage depends upon the difference in head between the two units. Since head is a function of pressure and elevation, flow occurs from areas of higher to areas of lower head.

The amount of water that can be withdrawn from an aquifer depends chiefly upon:

- the aquifer's capability to transmit water from areas of recharge to the points of withdrawal;

- the amount of water available in the areas of recharge to replace the water that moves to points of withdrawal; and
- the amount of water available from storage as the water level declines.

The coefficient of permeability, P, of material comprising an aquifer is a measure of the material's capacity to transmit water. The coefficient of permeability was expressed by Meinzer (1932) as the rate of flow of water in gallons per day through a cross-sectional area of 1 square foot under a hydraulic gradient of 100 percent. Theis (1935) introduced the term coefficient of transmissibility, T, which is expressed as the rate of flow of water at the prevailing water temperature in gallons per day, through a vertical strip of the aquifer under a hydraulic gradient of 100 percent. A hydraulic gradient of 100 percent means a 1 foot drop in head-level in 1 foot of horizontal flow. Thus, the coefficient of transmissibility, T, is equal to the coefficient of permeability, P, multiplied by the thickness of the aquifer. The term "coefficient of transmissibility" has been replaced by the newer term "transmissivity" which is used in this report.

The amount of water available from storage as the water level declines depends on the coefficient of storage of the aquifer. The coefficient of storage is the volume of water that an aquifer releases from or takes into storage per unit change in the component of head normal to that surface.

The coefficients of transmissivity and storage can be used to estimate the rate and amount of lowering in water levels to be expected at various rates and distribution of pumping, to determine optimum well yields and to determine the proper spacing of wells (Theis 1935).

REGIONAL CHARACTERISTICS

Three aquifers underlie central Hardee County (Figure 6-1). The surficial water table aquifer is present at the land surface and consists of about 60 feet of sand and sandy clay. It is underlain by the Secondary Artesian Aquifer which includes the Hawthorn Formation and the Tampa Limestone. This aquifer consists of about 230 feet of dolomitic limestone, sandy clay, and small amounts of chert. It is separated from the Surficial Aquifer by the relatively impermeable parts of the matrix (phosphate bearing zone) at the base of the surficial deposits. There is a relatively impermeable clay bed at the top of the Hawthorn Formation which is considered to be a leaky confining bed. The Floridan Aquifer includes a thick series of permeable beds of limestone, which from top to bottom are the Suwannee Limestone, the Ocala Group, and the Avon Park Limestone (see Table 6-1) (Wilson 1975). This sequence extends from approximately 300 feet to 1700 feet below ground surface.

SURFICIAL AQUIFER

The water in the shallow Surficial Aquifer is recharged by infiltration of rain or streamflow and occurs under unconfined conditions. The level of the water table in the Surficial Aquifer varies in response to changes in rainfall, evapotranspiration, baseflow support to streams and leakage into the Secondary Artesian Aquifer. The geologic materials that make up the Surficial Aquifer include the permeable beds of sand and sandy clay from the land surface to the top of the Hawthorn Formation. Wells tapping this aquifer yield up to 200 gallons per minute (gpm) in some areas and are widely used for domestic supplies. A geologic cross section (Figure 6-2) prepared from detailed test drilling on the property indicates the thickness of the Surficial Aquifer ranges from 20 to 100 feet and averages about 60 feet. The Surficial Aquifer is thickest at the northeastern boundary of the Farmland property.

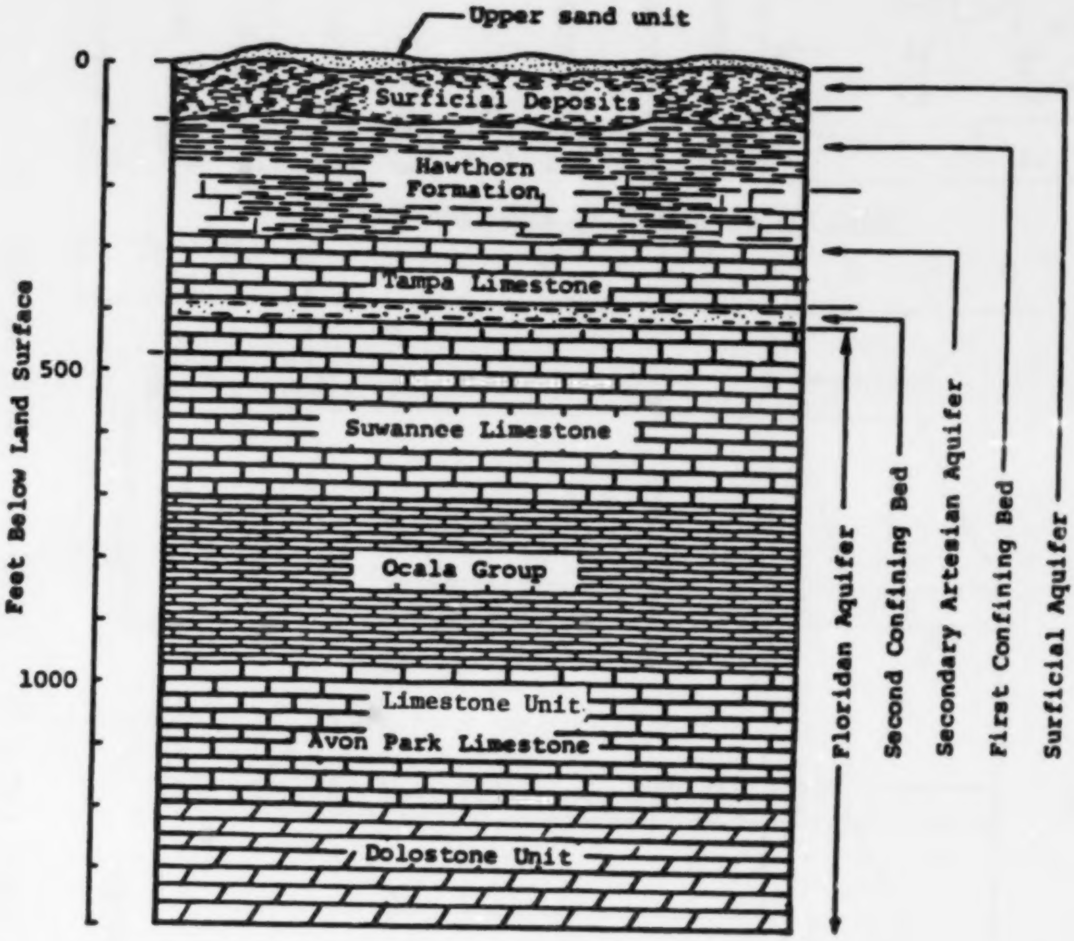

Upper sand unit
0
500
1000
Feet Below Land Surface
Surficial Deposits
Hawthorn Formation
Tampa Limestone
Suwannee Limestone
Ocala Group
Limestone Unit
Avon Park Limestone
Dolostone Unit
Floridan Aquifer
Second Confining Bed
Secondary Artesian Aquifer
First Confining Bed
Surficial Aquifer

FIGURE 6-1. HYDROGEOLOGIC CROSS SECTION.

SOURCE: FARMLAND INDUSTRIES, INC., DRI, JUNE 1979

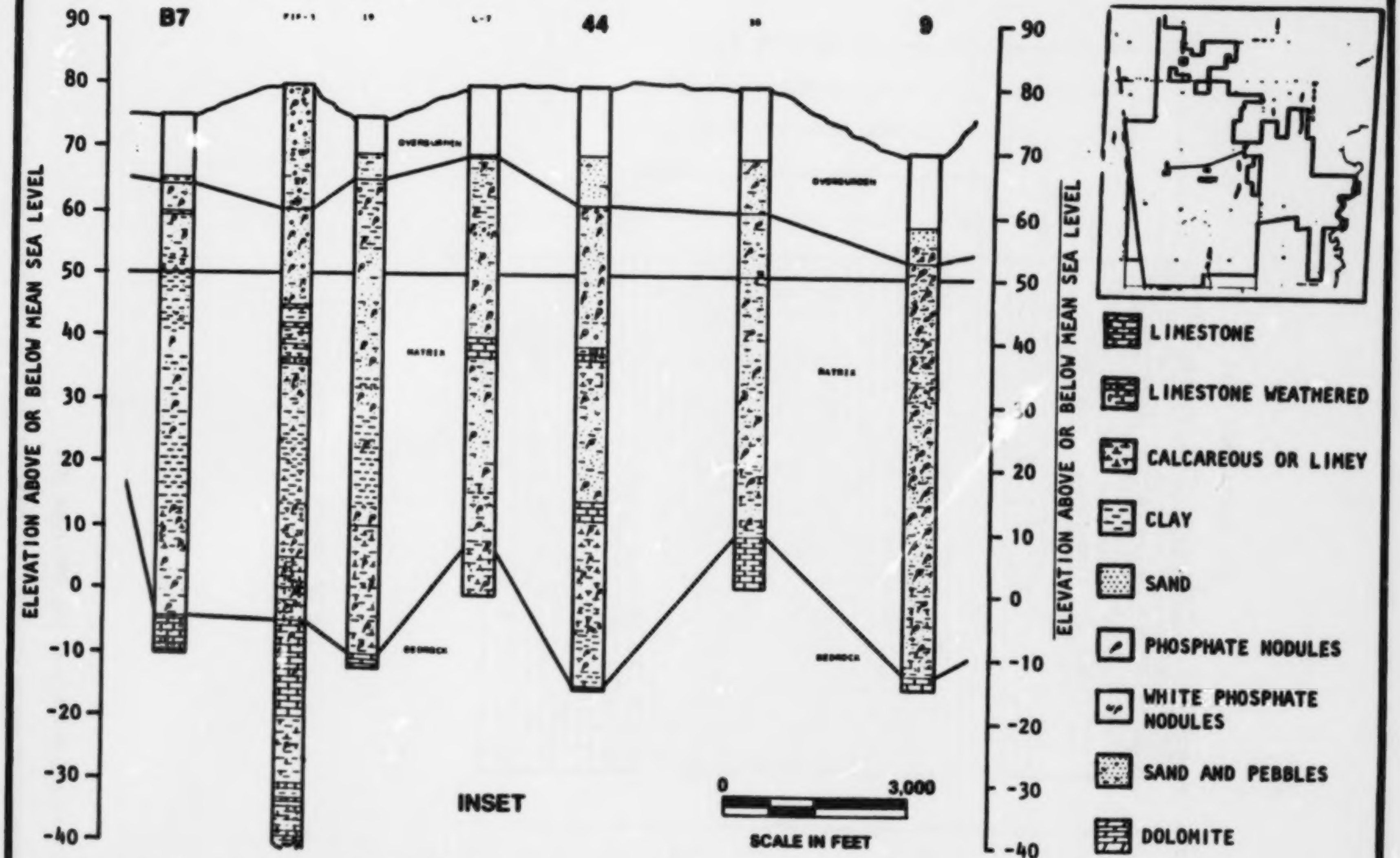

ELEVATION ABOVE OR BELOW MEAN SEA LEVEL
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
B7
19
44
9
OVERBURDEN
MATRIX
BEDROCK
INSET
0
3,000
SCALE IN FEET
LIMESTONE
LIMESTONE WEATHERED
CALCAREOUS OR LIMEY
CLAY
SAND
PHOSPHATE NODULES
WHITE PHOSPHATE NODULES
SAND AND PEBBLES
DOLOMITE

FIGURE 6-2. REPRESENTATIVE GEOLOGIC CROSS SECTION OF THE SURFICIAL AQUIFER.

SOURCE: FARMLAND INDUSTRIES, INC., DRI, JUNE 1979

Seasonal Variation

Water levels in three wells on the Farmland mine property (Figure 6-3) were monitored monthly by P.E. LaMoreaux & Associates, Inc. (PELA) between May 1977 and August 1978 to provide baseline data prior to mine development and to aid in determining the baseflow of streams on the mine site (PELA 1978). The water table generally reaches a seasonal low in May and highs between June and September. The dry season decline in water table under the mine site was measured to be 2 to 8 feet during the period of monitoring. Comparison of these differences in seasonal fluctuations to the depth of the aquifer and the percentage of sand in the aquifer indicate that the areas of greatest water table fluctuation occur where the percentage of sand is greatest and they bear little relation to the depth of the aquifer. Hydrographs of the mine site Surficial Aquifer wells are presented in Figures 6-4, 6-5, and 6-6. The lowest Surficial Aquifer water level recorded was 11.63 feet below land surface (69.87 feet above mean sea level [MSL]) on July 15, 1977, in well CP-1. The highest water level recorded was 1.64 feet below land surface (92.27 feet above MSL) on July 7, 1978, in well CP-2. Daily water levels recorded in wells CP-1, CP-2, and CP-3 are presented in Tables A-1, A-2, and A-3 (see Appendix A).

Monthly observations of 22 additional Surficial Aquifer piezometers (2 inch) on the mine property were also made by PELA (1978). These data are presented in Table A-4. The lowest Surficial Aquifer water level observed was 10.03 feet below land surface (65.35 feet above MSL) on June 14, 1977, in piezometer FP-8. The highest water level observed was 0.84 feet above land surface (66.04 feet above MSL) on August 22, 1978, in piezometer FP-16.

Test Pumping

Two Surficial Aquifer pumping tests were performed on the Farmland property at the locations shown on Figure 6-3. For test 1, water levels were measured at frequent intervals in the well to be pumped and the observation wells during the 24 hours prior to the pumping test.

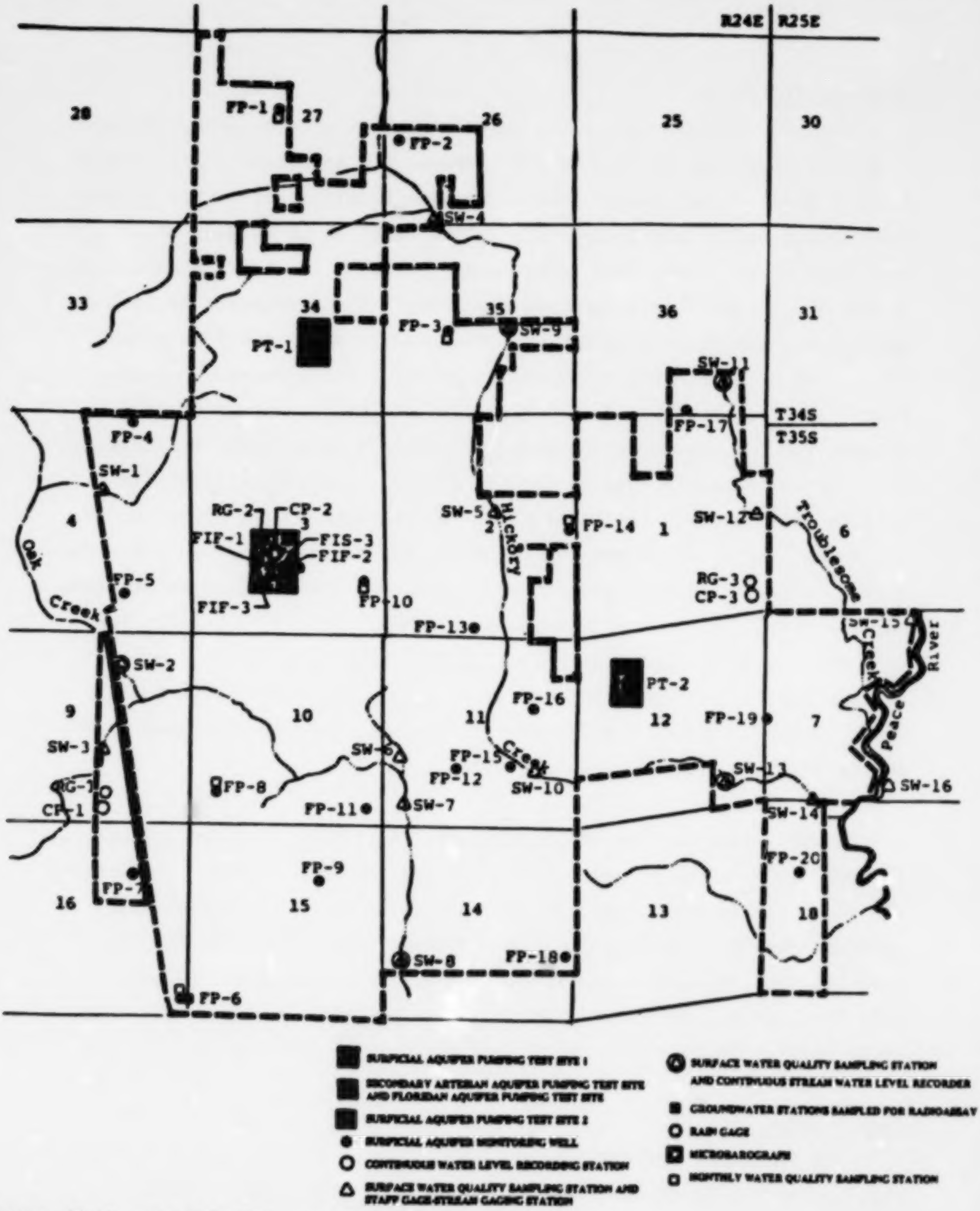

R24E
R25E
T34S
T35S
28
27
26
25
30
33
34
35
36
31
4
2
1
6
9
10
11
12
7
16
15
14
13
18
FP-1
FP-2
FP-3
FP-4
FP-5
FP-6
FP-7
FP-8
FP-9
FP-10
FP-11
FP-12
FP-13
FP-14
FP-15
FP-16
FP-17
FP-18
FP-19
FP-20
SW-1
SW-2
SW-3
SW-4
SW-5
SW-6
SW-7
SW-8
SW-9
SW-10
SW-11
SW-12
SW-13
SW-14
SW-15
SW-16
PT-1
PT-2
RG-1
CP-1
RG-2
CP-2
3
RG-3
CP-3
FIF-1
FIF-2
FIF-3
FIS-3
Oak Creek
Hickory Creek
Troublesome Creek
Peace River
SURFICIAL AQUIFER PUMPING TEST SITE 1
SECONDARY ARTESIAN AQUIFER PUMPING TEST SITE AND FLORIDAN AQUIFER PUMPING TEST SITE
SURFICIAL AQUIFER PUMPING TEST SITE 2
SURFICIAL AQUIFER MONITORING WELL
CONTINUOUS WATER LEVEL RECORDING STATION
SURFACE WATER QUALITY SAMPLING STATION AND STAFF GAGE-STREAM GAGING STATION
SURFACE WATER QUALITY SAMPLING STATION AND CONTINUOUS STREAM WATER LEVEL RECORDER
GROUNDWATER STATIONS SAMPLED FOR RADIOASSAY
RAIN GAGE
MICROBAROGRAPH
MONTHLY WATER QUALITY SAMPLING STATION
N
0
2,000
4,000
SCALE IN FEET

FIGURE 6-3. LOCATIONS OF HYDROLOGIC DATA COLLECTION STATIONS.

SOURCE: FARMLAND INDUSTRIES, INC., DRI, JUNE 1979

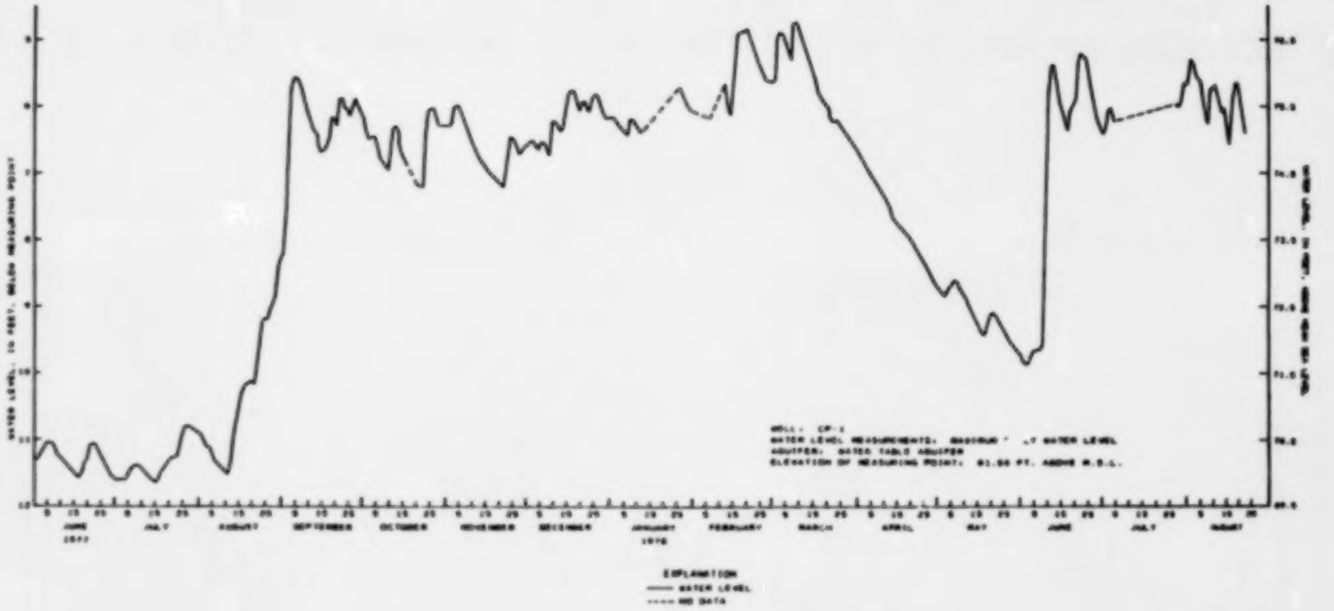


FIGURE 6-4. HYDROGRAPH OF SURFICIAL AQUIFER WELL CP-1 ON THE FARMLAND INDUSTRIES, INC. PROPERTY IN HARDEE COUNTY, FLORIDA; JUNE 1977 - AUGUST 1978.

SOURCE: P.E. LA MOREAUX & ASSOCIATES, INC. (1978)

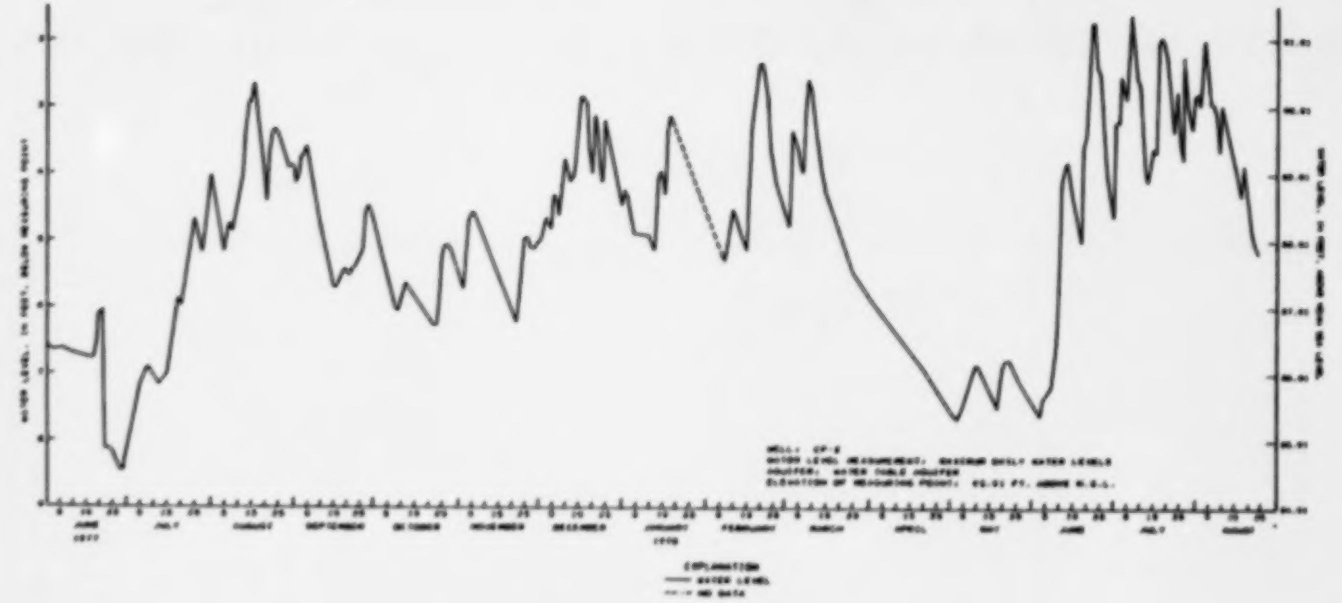


FIGURE 6-5. HYDROGRAPH OF SURFICIAL AQUIFER WELL CP-2 ON THE FARMLAND INDUSTRIES, INC. PROPERTY IN HARDEE COUNTY, FLORIDA; JUNE 1977 - AUGUST 1978.

SOURCE: P.E. LA MOREAUX & ASSOCIATES, INC. (1978)

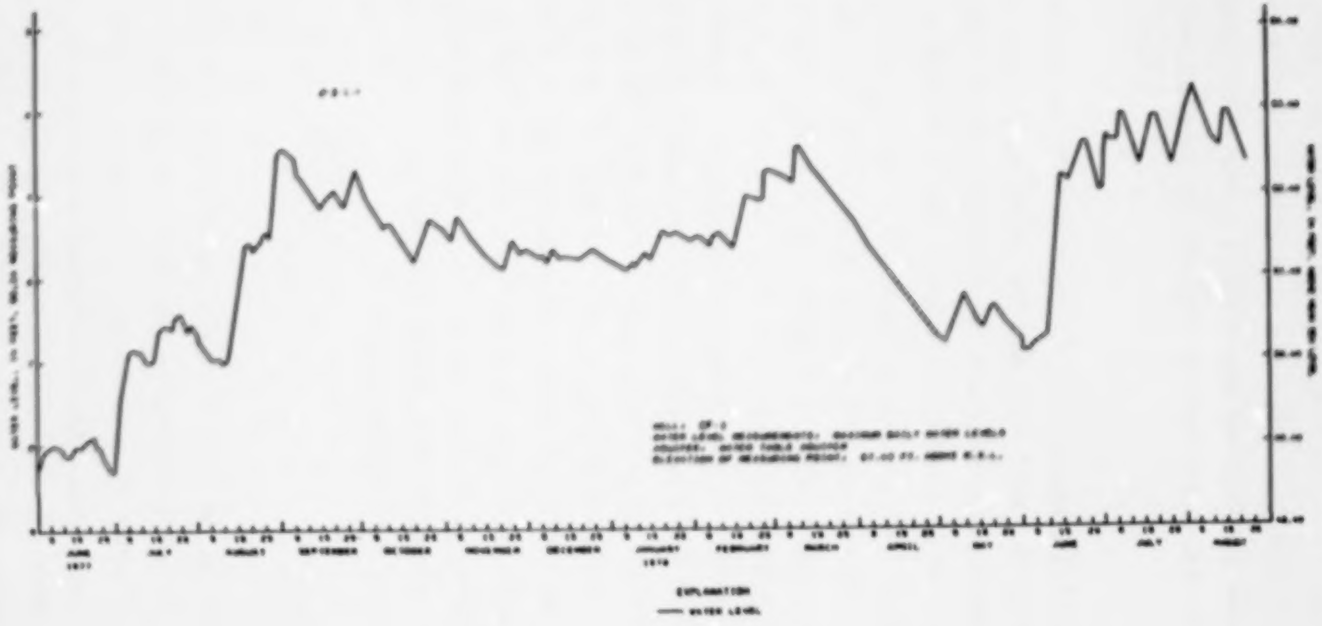


FIGURE 6-6. HYDROGRAPH OF SURFICIAL AQUIFER WELL CP-3 ON THE FARMLAND INDUSTRIES, INC. PROPERTY IN HARDEE COUNTY, FLORIDA; JUNE 1977 - AUGUST 1978.

SOURCE: P.E. LA MOREAUX & ASSOCIATES, INC. (1978)

Well PT-1 was pumped continuously at an average rate of 41 gpm from 8:00 a.m. on November 8, 1977, to 8:00 a.m. on November 10, 1977. Water levels were measured at frequent intervals in pumped well PT-1 and the observation wells during pumping and the first 3 hours after pumping ceased. The test well layout and hydrographs of the pumping test are shown in Figure 6-7.

For Surficial Aquifer pumping test 2, water levels were measured at frequent intervals in pumped well PT-2 and the observation wells for the 20 hours immediately preceding the start of pumping. Pumped well PT-2 was pumped continuously at an average rate of 38 gpm from 8:00 a.m. on November 15, 1977, until 8:00 a.m. on November 17, 1977, a period of 48 hours. Water levels were measured in pumped well PT-2 and in the observation wells at frequent intervals during the pumping period and for the first 3 hours after pumping ceased. The test well layout and hydrographs of the pumping test are shown in Figure 6-8. Construction diagrams for the pumping and observation wells are shown in Figure 6-9. The tests of the Surficial Aquifer were analyzed by the Boulton Delayed Yield Method (Boulton 1954; 1963; 1964). The results of the two pumping tests carried out on the Surficial Aquifer are summarized in Table 6-2. The average value of transmissivity obtained from the Farmland tests is very similar to that obtained in studies on the nearby Mississippi Chemical Company (MCC) property (MCC 1976), but the value of storativity is approximately 10 times that obtained by MCC.

SECONDARY ARTESIAN AQUIFER

The Secondary Artesian Aquifer includes the Hawthorn Formation and the Tampa Limestone. The Hawthorn Formation in the Central Phosphate District is commonly referred to as bedrock. It consists of gray to greenish gray, sandy, calcareous clay interbedded with cream to tan weathered limestone. Both the clay and limestone contain variable quantities of chert, phosphatic material, dolomite, and fossils. The

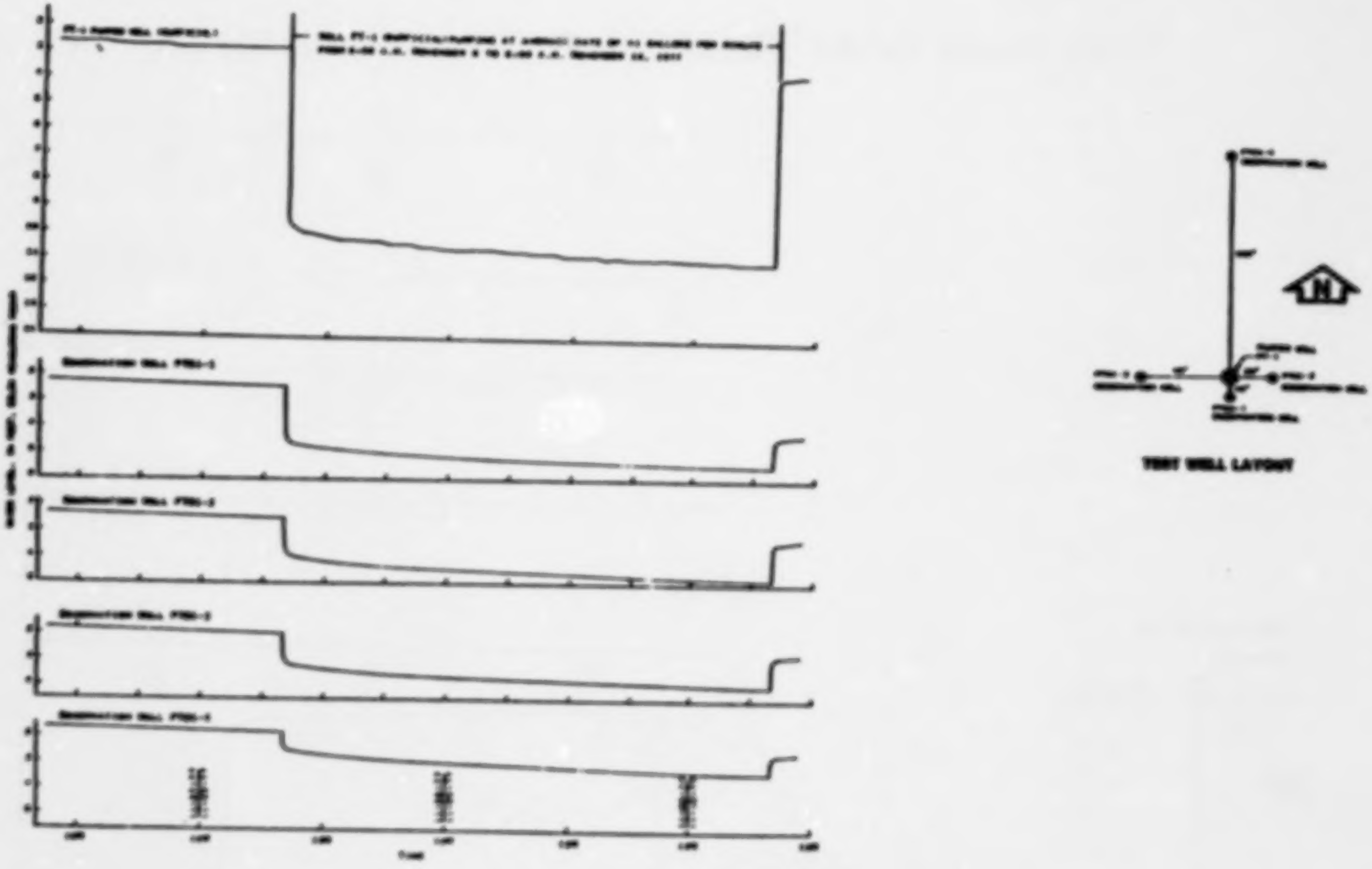


FIGURE 6-7. HYDROGRAPHS AND TEST WELL LAYOUT SURFICIAL AQUIFER PUMPING TEST 1.

SOURCE: FARMLAND INDUSTRIES, INC., DRI, JUNE 1979

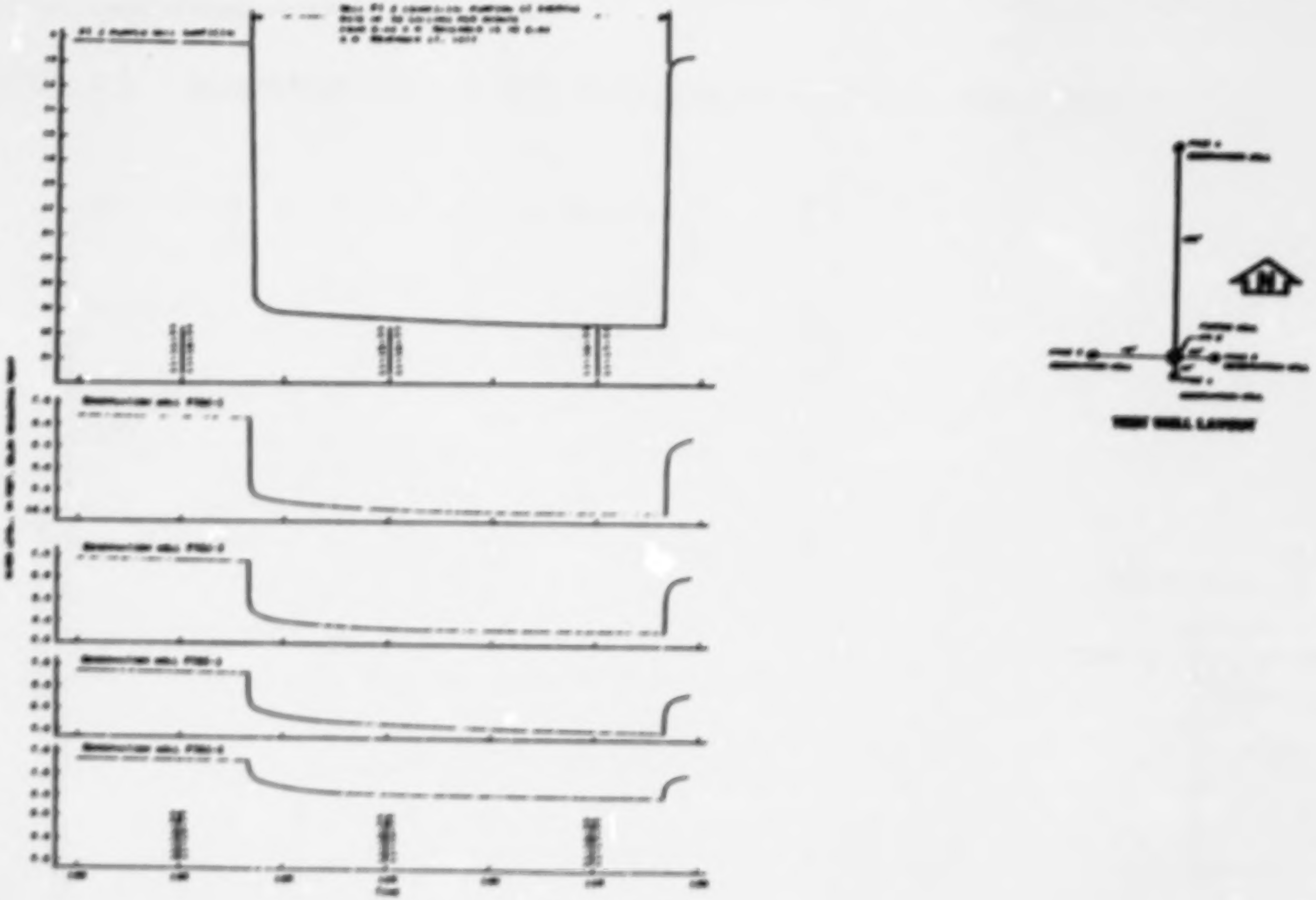


FIGURE 6-8. HYDROGRAPHS AND TEST WELL LAYOUT SURFICIAL AQUIFER PUMPING TEST 2.

SOURCE: FARMLAND INDUSTRIES, INC., DRI, JUNE 1979

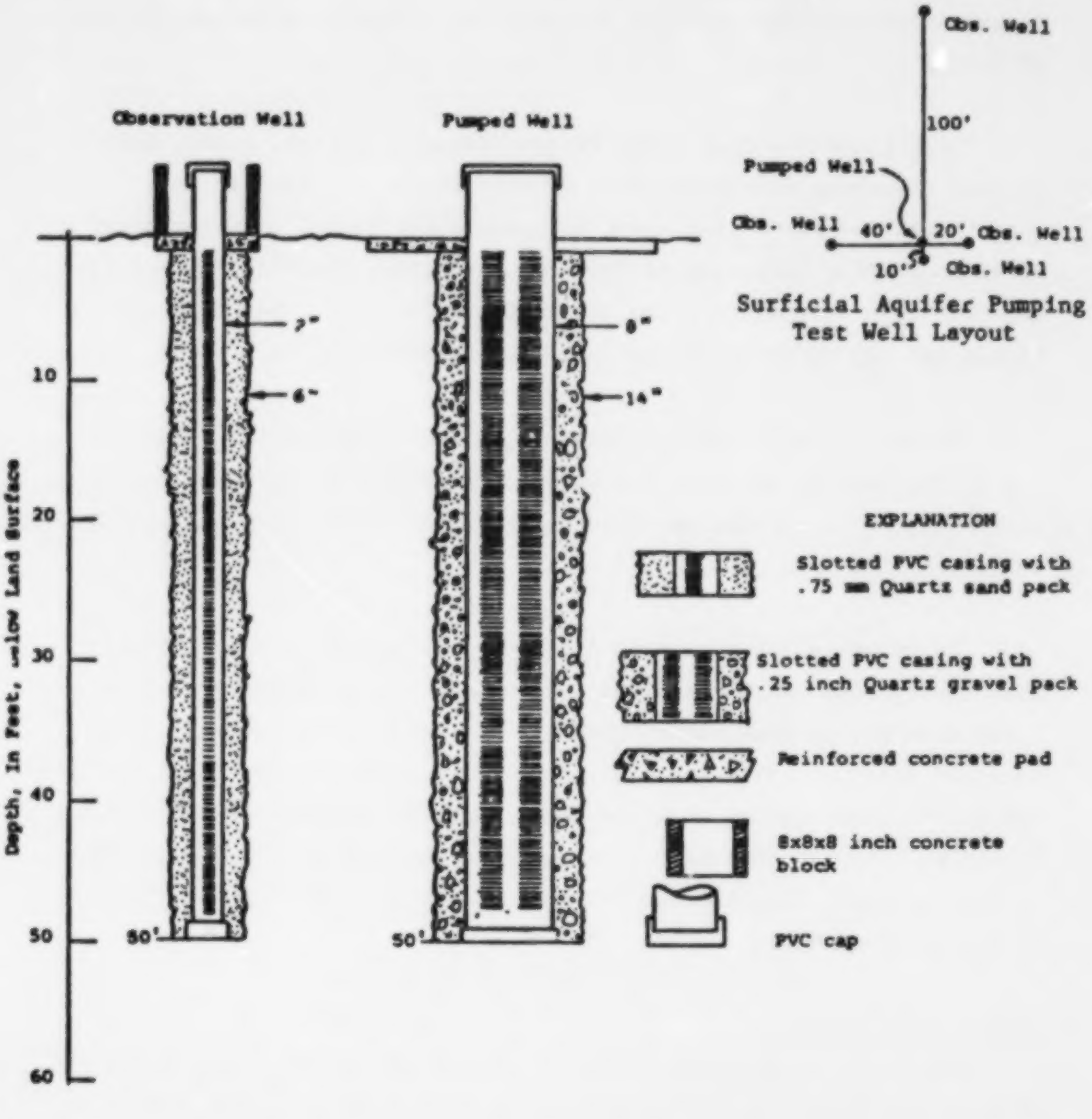

Observation Well
Pumped Well
2"
6"
8"
14"
10
20
30
40
50
60
50'
50'
Depth, In Feet, Below Land Surface
Obs. Well
100'
Pumped Well
Obs. Well
40'
20'
Obs. Well
10'
Obs. Well
Surficial Aquifer Pumping Test Well Layout
EXPLANATION
Slotted PVC casing with .75 mm Quartz sand pack
Slotted PVC casing with .25 inch Quartz gravel pack
Reinforced concrete pad
8x8x8 inch concrete block
PVC cap

FIGURE 6-9. CONSTRUCTION DIAGRAMS FOR SURFICIAL AQUIFER PUMPING TEST WELLS ON THE FARMLAND INDUSTRIES, INC. SITE.

SOURCE: FARMLAND INDUSTRIES, INC., HARDEE COUNTY MASTER PLAN, JUNE 1979

Hawthorn surface is irregular and severely dissected because of post-depositional erosional process and solution cavity development (Wilson 1975).

Tampa Limestone is a white to tan, dense to porous, sandy, fossiliferous limestone with silicified dolomitic layers. Fine grained phosphorite and chert also occur locally in the Tampa. The Secondary Artesian Aquifer is separated from the underlying Floridan Aquifer by a bed of clay at the base of the Tampa Limestone. This unit is a confining bed and is 10 to 20 feet thick under the Farmland property.

The top of the Secondary Artesian Aquifer conforms generally to the top of the bedrock and is about 60 feet below the surface of the property. The bottom of the aquifer is approximately 600 feet below ground surface at the site.

The water in the Secondary Artesian Aquifer occurs under artesian conditions. Because the confining beds are not completely impermeable, local downward leakage occurs from the surficial water table aquifer into the Secondary Artesian Aquifer. Upward leakage occurs from the deeper Floridan Aquifer when the potentiometric surface of the Floridan is higher than that of the Secondary Artesian Aquifer. Wells developed in the Secondary Artesian Aquifer yield as much as 1000 gpm in the area of the proposed mine.

Seasonal Variation

The level of the potentiometric surface of the Secondary Artesian Aquifer was monitored with a continuous water level recorder from September 2, 1977, through August 22, 1978 (see Table A-5). Figure 6-10 shows the highest water level in the well FIS-3 for each day of observation. During the period of record, the water level in well FIS-3 attained a high level of 52.40 feet above MSL on August 22, 1978, and a low level of 29.80 feet above MSL on May 4, 1978. Seasonal variation is generally similar to that in the underlying Floridan Aquifer.

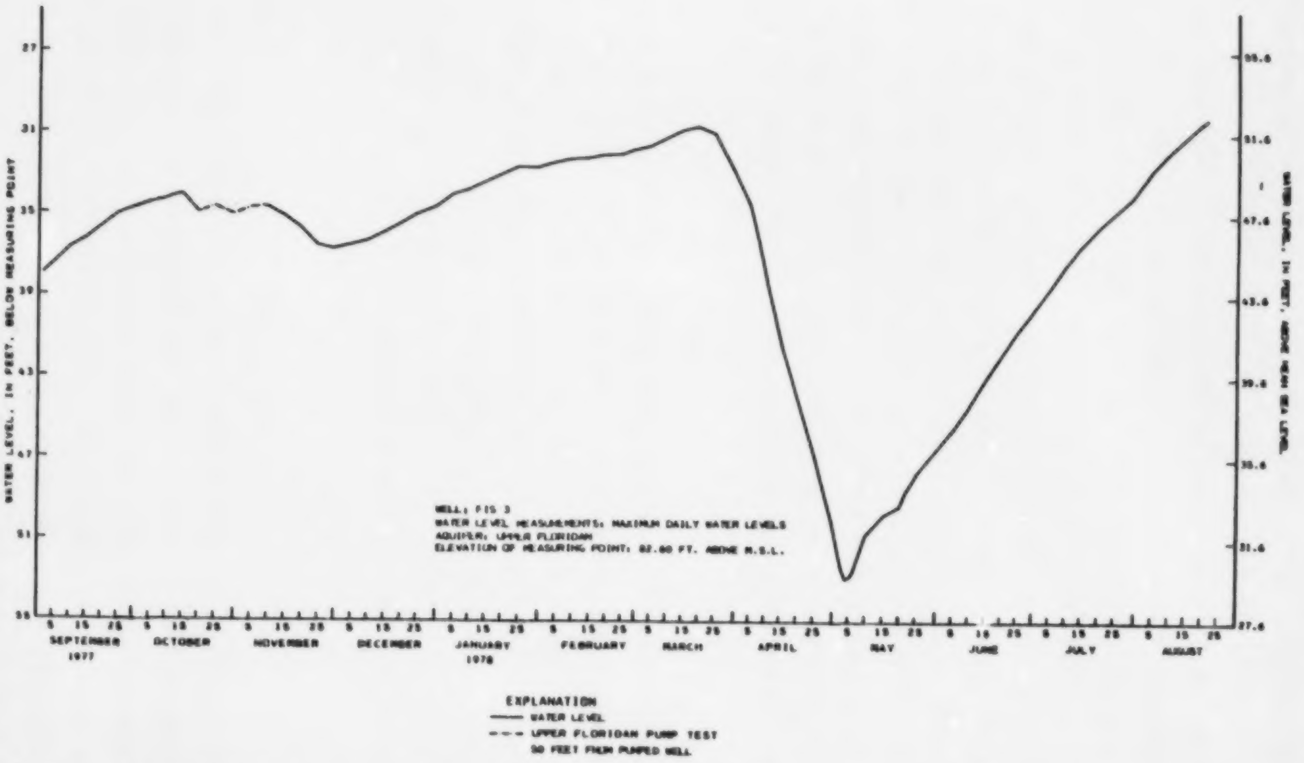


FIGURE 6-10. HYDROGRAPH OF UPPER FLORIDAN (SECONDARY ARTESIAN) AQUIFER WELL FIS-3 ON THE FARMLAND INDUSTRIES, INC. MINE SITE IN HARDEE COUNTY FLORIDA; SEPTEMBER 1977 - AUGUST 1978.

SOURCE: P.E. LA MOREAUX & ASSOCIATES, INC. (1978)

Test Pumping

A pumping test of the Secondary Artesian Aquifer was conducted from July 9, 1977, to July 16, 1977. Well FIS-1 was pumped at an average rate of 340 gpm from 10:00 a.m. on July 12, 1977, to 10:00 a.m. on July 15, 1977, a period of 72 hours. Wells FIS-2 and FIS-3 were used as Secondary Artesian Aquifer observation wells during the test. In addition, Surficial Aquifer well CP-2 and Floridan Aquifer observation well FIF-3 were equipped with continuous water level recorders to determine if pumping of the Secondary Artesian Aquifer affected water levels in these aquifers. Water levels were also measured in observation well SWFWMD-2, which is developed in the Secondary Artesian Aquifer. The location of the pumping test site is shown in Figure 6-3. The test well layout and hydrographs of the water level fluctuations from the pumping test are shown in Figure 6-11. Well construction diagrams for the pumped well and observation wells are shown in Figure 6-12.

The pumping test of the Secondary Artesian Aquifer was analyzed by the method of Hantush and Jacob (1955), as modified by Cooper (1963). The results of the pumping test on the Secondary Artesian Aquifer are given in Table 6-3. The values for transmissivity obtained at the Farmland site are similar to those obtained at the adjoining MCC site; however, the values of storativity are one to two orders of magnitude smaller than those obtained at the MCC property.

FLORIDAN AQUIFER

The Floridan Aquifer is the primary source of water supply for Hardee County and much of Florida. From top to bottom the aquifer includes the Suwannee Limestone, the Ocala Group, and the Avon Park Limestone. The Avon Park Limestone is the most prolific producer of water. The aquifer is tapped by many wells throughout the area and yields of 5000 gpm per well are common.

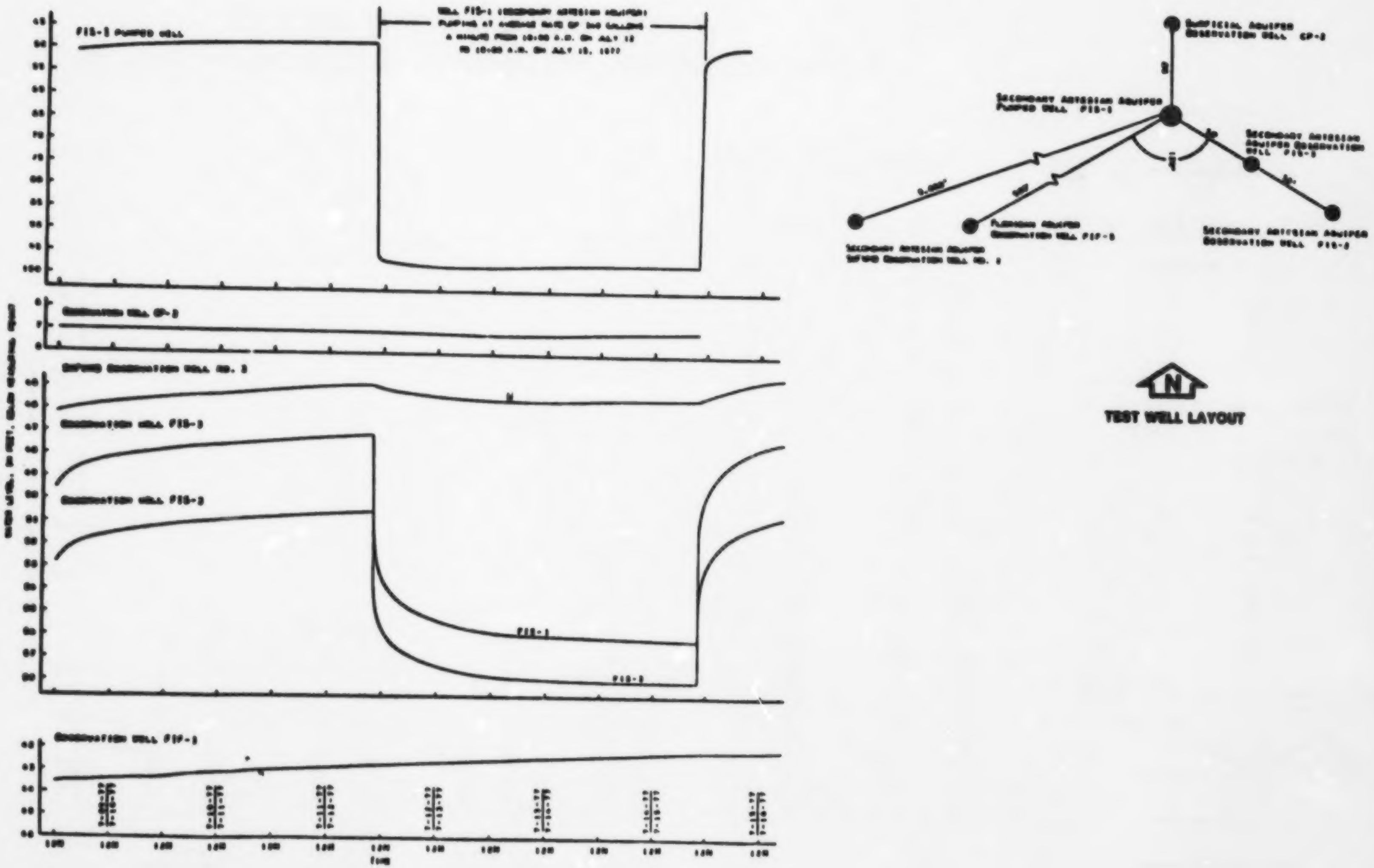
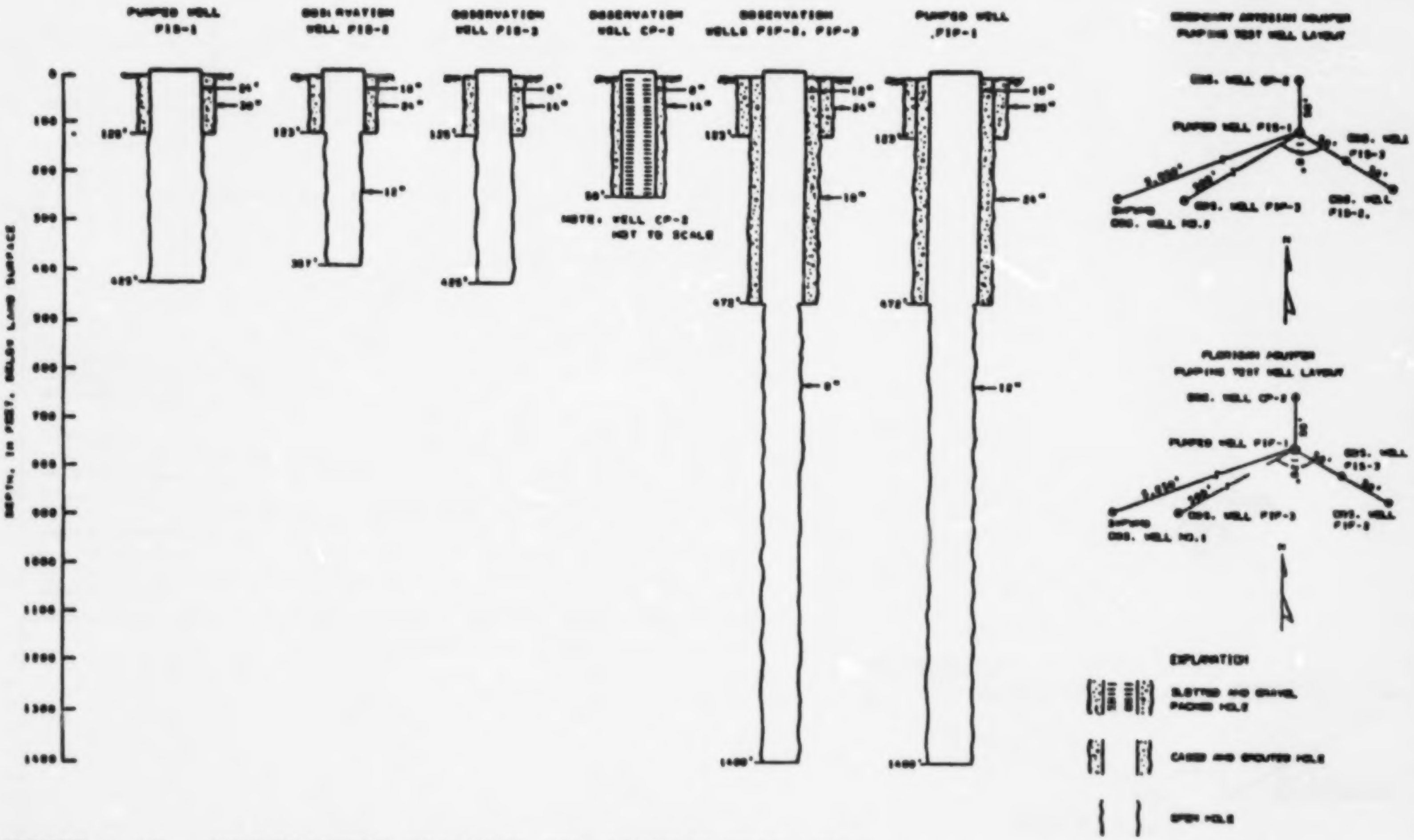


FIGURE 6-11. HYDROGRAPHS AND TEST WELL LAYOUT SECONDARY ARTESIAN AQUIFER PUMPING TEST.

SOURCE: FARMLAND INDUSTRIES, INC., DRI, JUNE 1979



PUMPED WELL FIS-1
OBSERVATION WELL FIS-2
OBSERVATION WELL FIS-3
OBSERVATION WELL CP-2
OBSERVATION WELLS FIP-2, FIP-3
PUMPED WELL FIP-1
DEPTH, IN FEET, BELOW LAND SURFACE
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
NOTE: WELL CP-2 NOT TO SCALE
472'
1400'
SECONDARY ARTESIAN AQUIFER PUMPING TEST WELL LAYOUT
OBS. WELL CP-2
PUMPED WELL FIS-1
OBS. WELL FIS-3
OBS. WELL FIS-2
OBS. WELL FIP-3
OBS. WELL NO.1
N
FLORIDAN AQUIFER PUMPING TEST WELL LAYOUT
PUMPED WELL FIP-1
OBS. WELL FIP-2
EXPLANATION
SLOTTED AND GRAVEL PACKED HOLE
CASED AND GROUTED HOLE
OPEN HOLE

FIGURE 6-12. CONSTRUCTION DIAGRAMS FOR AQUIFER TEST WELLS, FARMLAND INDUSTRIES, INC. SITE.

SOURCE: FARMLAND INDUSTRIES, INC., HARDEE COUNTY MASTER PLAN, JUNE 1979

The Suwannee Limestone is the only formation of Oligocene Age in this area and is about 250 feet thick. A sharp lithologic change from clay of the Tampa Formation to limestone identifies the upper contact. The limestone is cream colored and has an abundance of molluscan and bryozoan fossils. There is much less phosphate in the Suwannee Limestone than in the overlying formations and the limestone has visible porosity. The formation contacts limestones of the Ocala Group at a depth of about 700 feet.

Underlying the Suwannee Limestone is the Eocene Ocala Group of Jackson Age (Puri 1953) which with increasing depth in descending order consits of the Crystal River, Williston, and Inglis Formations. They are combined in this text as the Ocala Group. The upper limestones are white to cream colored and highly fossiliferous. The foraminiferal genus Lepidocyclina is extremely abundant and in some sections almost makes up the entire rock. The lower limestones are yellowish-brown, dolomitic and finely crystalline. At the mine site the Ocala Group is approximately 280 feet thick and contacts limestones of the Avon Park Formation at approximately 980 feet below ground surface.

The Eocene Avon Park Limestone is of upper Claiborne Age. The upper 200 feet consists of dolomitic limestone layers interbedded with the light tan limestone and pelletoidal and foraminiferal limestone. The top of dolostone unit of the Avon Park Limestone (Wilson 1975) occurs at a depth of about 1190 feet. This unit is a dark, yellowish-brown, granular dolostone. The unit extends to at least 1300 feet at the deepest well on the site, and probably extends to 1600 or 1700 feet.

Many wells drilled in the area near the Farmland property penetrate fractured and cavernous zones in the Avon Park Limestone. Wells on the neighboring MCC property penetrated large cavities in the Ocala Group also. None of the wells on the Farmland property penetrated any significant cavernous zones.

Documented results of exploratory drilling have verified the existence of a relatively impermeable evaporite stratum at the base of the Avon Park Limestone. This stratum was encountered at a depth of about 1600 feet at the CF Industries site approximately 9 miles north-northwest of the Farmland mine site. The transmissivity of the Lake City Limestone, which underlies this stratum and the Floridan Aquifer, was calculated to be very low (PELA 1977). Thus, an impermeable zone separates the fresh water in the Floridan Aquifer from the highly mineralized water found in the Lake City and Oldsmar Limestones. This impermeable zone would prevent or greatly retard the upward movement of mineralized water induced by lowering of the potentiometric surface. Based on the formation thickness and dips in the area (PELA 1977), the depth to the impermeable zone beneath the Farmland mine site would be in the range of 1600 to 1700 feet. The salt water/fresh water interface calculated by using the Ghyben-Herzberg principal (Stringfield 1966) for conditions at the Farmland mine site in March 1978 was about 2100 feet below MSL.

Seasonal Variation

Water levels in the Floridan Aquifer were measured from September 1977 through May 1978 in well FIF-2 (see Table A-6 and Figure 6-13). The highest level recorded in the Avon Park Formation was 53 feet above MSL in March 1978, and the lowest level was 28 feet above MSL in May 1978. Typical seasonal variations of water levels in the Floridan Aquifer are shown by the hydrograph of well FIF-2 during the September 1977 - May 1978 period (Figure 6-14).

Test Pumping

After completing the pumping test on the Secondary Artesian Aquifer, wells FIS-1 and FIS-2 were deepened to about 1400 feet (the approximate depth of FIF-3) and designated as wells FIF-1 (formerly FIS-1) and FIF-2 (formerly FIS-2).

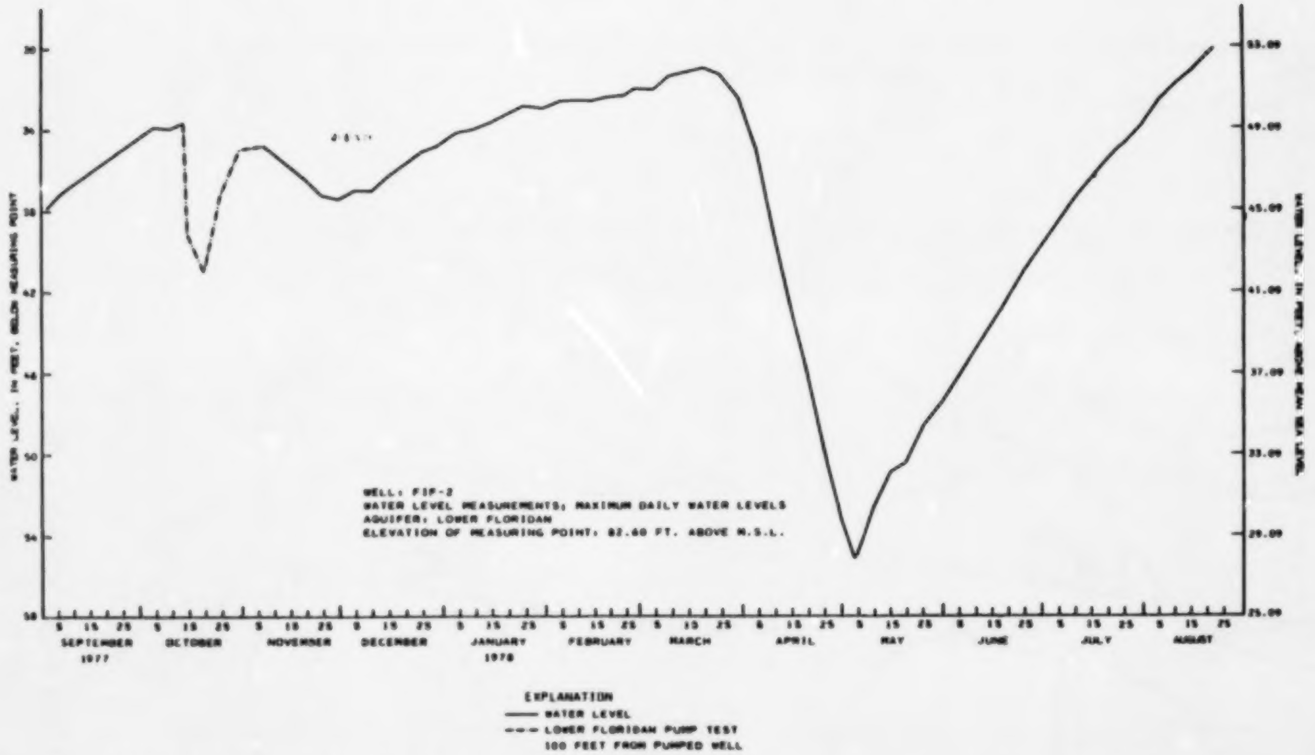
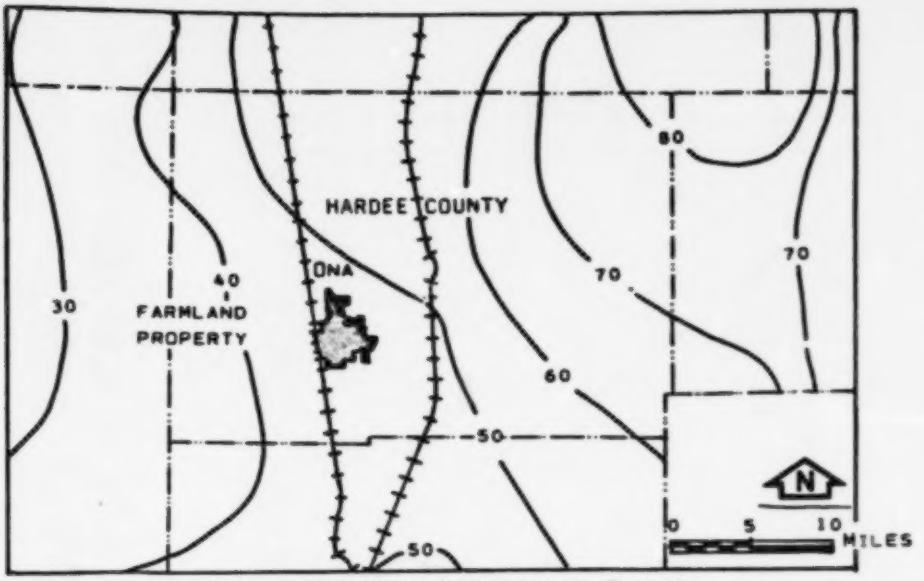
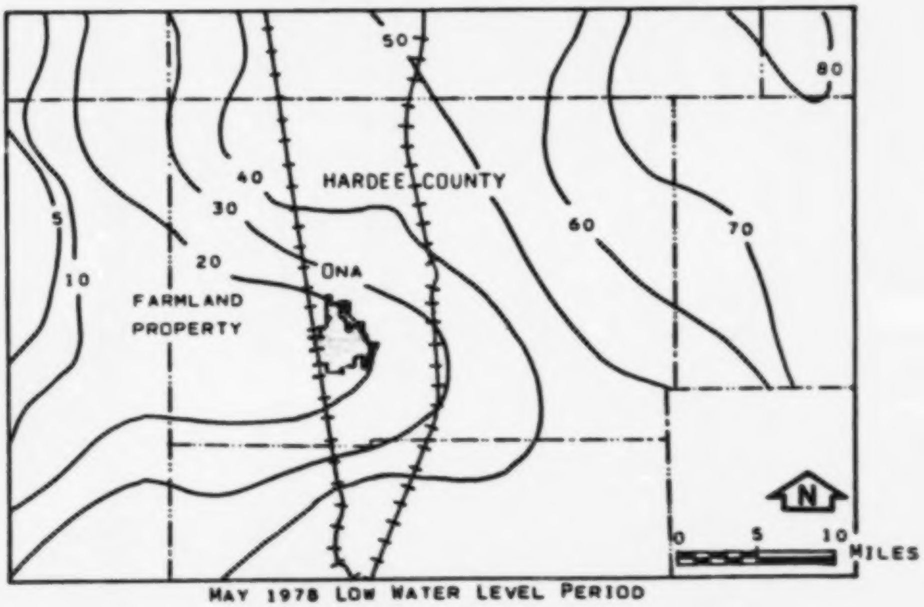


FIGURE 6-13. HYDROGRAPH OF FLORIDAN AQUIFER WELL FIF-2 ON THE FARMLAND INDUSTRIES, INC. PROPERTY IN HARDEE COUNTY, FLORIDA; SEPTEMBER 1977 - AUGUST 1978.

SOURCE: P.E. LA MOREAUX & ASSOCIATES, INC. (1978)


80
HARDEE COUNTY
70
70
ONA
40
30
FARMLAND
PROPERTY
60
50
50
N
0
5
10
MILES

SEPTEMBER 1977 HIGH WATER LEVEL PERIOD
IN FEET ABOVE MEAN SEA LEVEL


50
80
40
HARDEE COUNTY
30
5
60
70
20
ONA
10
FARMLAND
PROPERTY
N
0
5
10
MILES

MAY 1978 LOW WATER LEVEL PERIOD
IN FEET ABOVE MEAN SEA LEVEL

FIGURE 6-14. POTENTIOMETRIC SURFACE OF THE FLORIDAN AQUIFER HARDEE COUNTY, FLORIDA.

SOURCE: FARMLAND INDUSTRIES, INC., DRI, JUNE 1979

A pumping test of the Floridan Aquifer was conducted from September 28, 1977, to October 6, 1977. Wells FIF-2, FIF-3, and SWFWMD-1 were used as Floridan Aquifer observation wells during the test. In addition, Surficial Aquifer well CP-2 and Secondary Artesian Aquifer well FIS-3 were equipped with continuous water level recorders to determine if pumping of the Floridan Aquifer affected water levels in these aquifers. Well FIF-1 was pumped at an average rate of 3480 gpm from 10:00 a.m. on October 4, 1977, to 8:00 p.m. on October 6, 1977. This test was terminated early because of a malfunction of the diesel power plant which began at 2:00 p.m. on October 6, 1977. After recovery and stabilization, the test was resumed. Well FIF-1 began pumping at 2:00 a.m. on October 14, 1977, and was pumped continuously until 4:30 p.m. on October 24, 1977.

The location of the pumping test site is shown in Figure 6-3. The test well layout and hydrographs of the water fluctuations from the pumping test are shown on Figure 6-15. Well construction diagrams for the wells are shown on Figure 6-12.

Water level measurements in the pumped well, observation wells and selected wells within a 5-mile radius of pumped well FIF-1 were made periodically during and after the termination of the Floridan Aquifer pumping test. The measured wells were selected from a well inventory and are shown on Figure 6-16. A hydrograph of a long-term, USGS monitoring well located near the Farmland property boundary is shown for the year 1977 on Figure 6-17. The water level in this well, 3 miles away from the pumped well, remained at levels that are typical for the end of the wet season.

The results of the pumping test are given in Table 6-3. The values obtained for the transmissivity of the Floridan Aquifer at the Farmland site was about one-half that obtained at the MCC site. This difference could be due to the aquifer having better developed cavities at the MCC

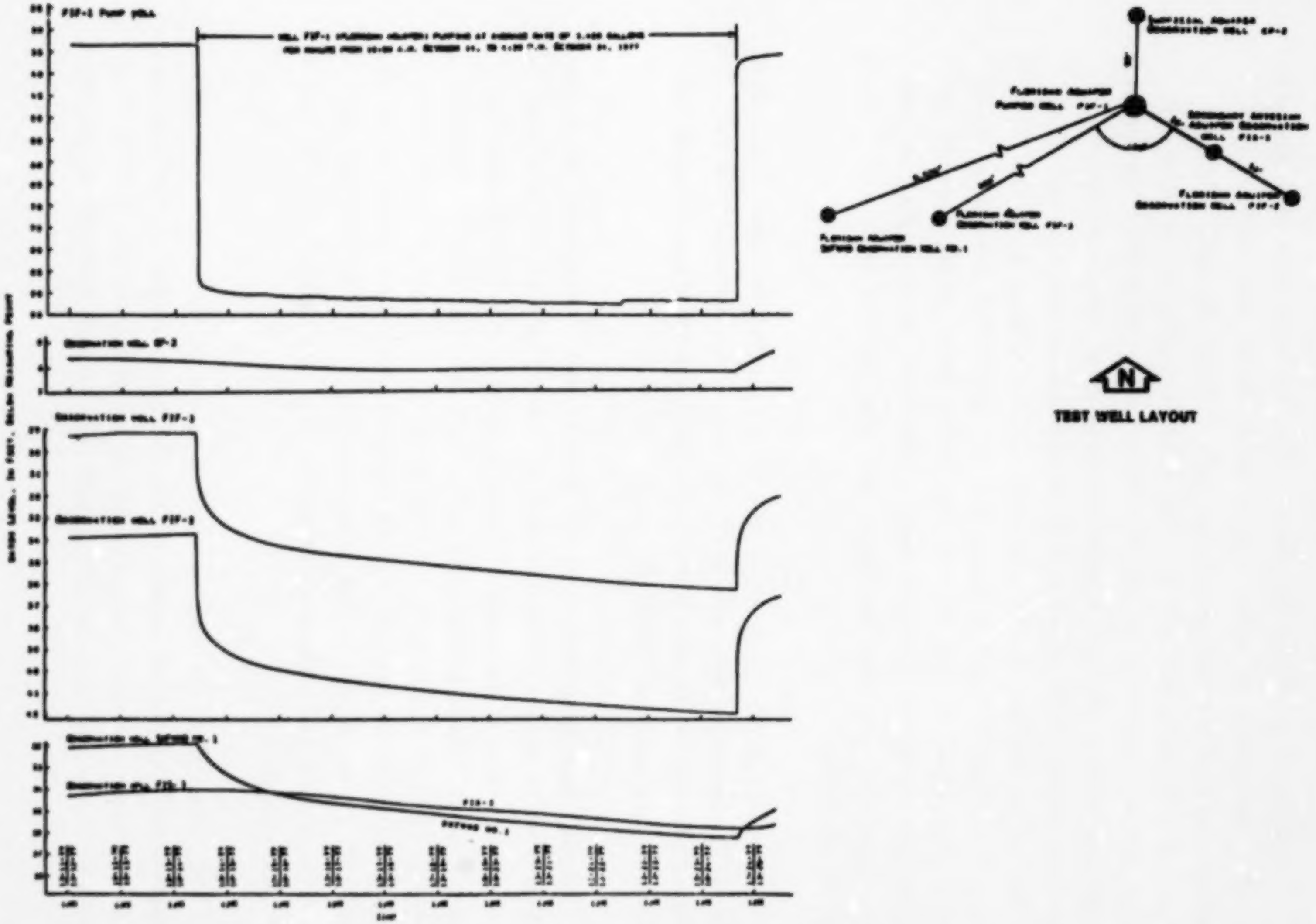


FIGURE 6-15. HYDROGRAPHS AND TEST WELL LAYOUT FLORIDAN AQUIFER PUMPING TEST.

SOURCE: FARMLAND INDUSTRIES, INC., DRI, JUNE 1979

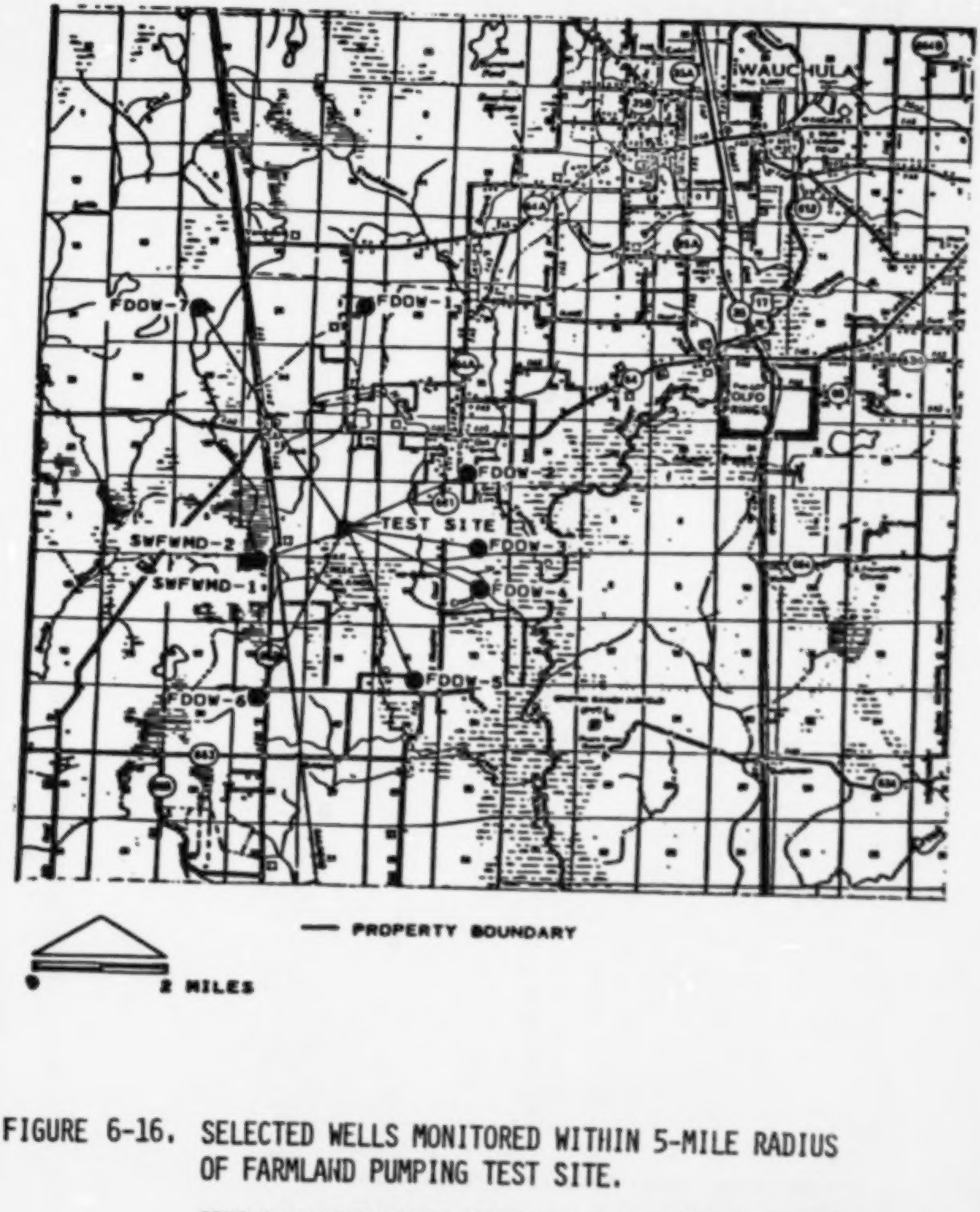
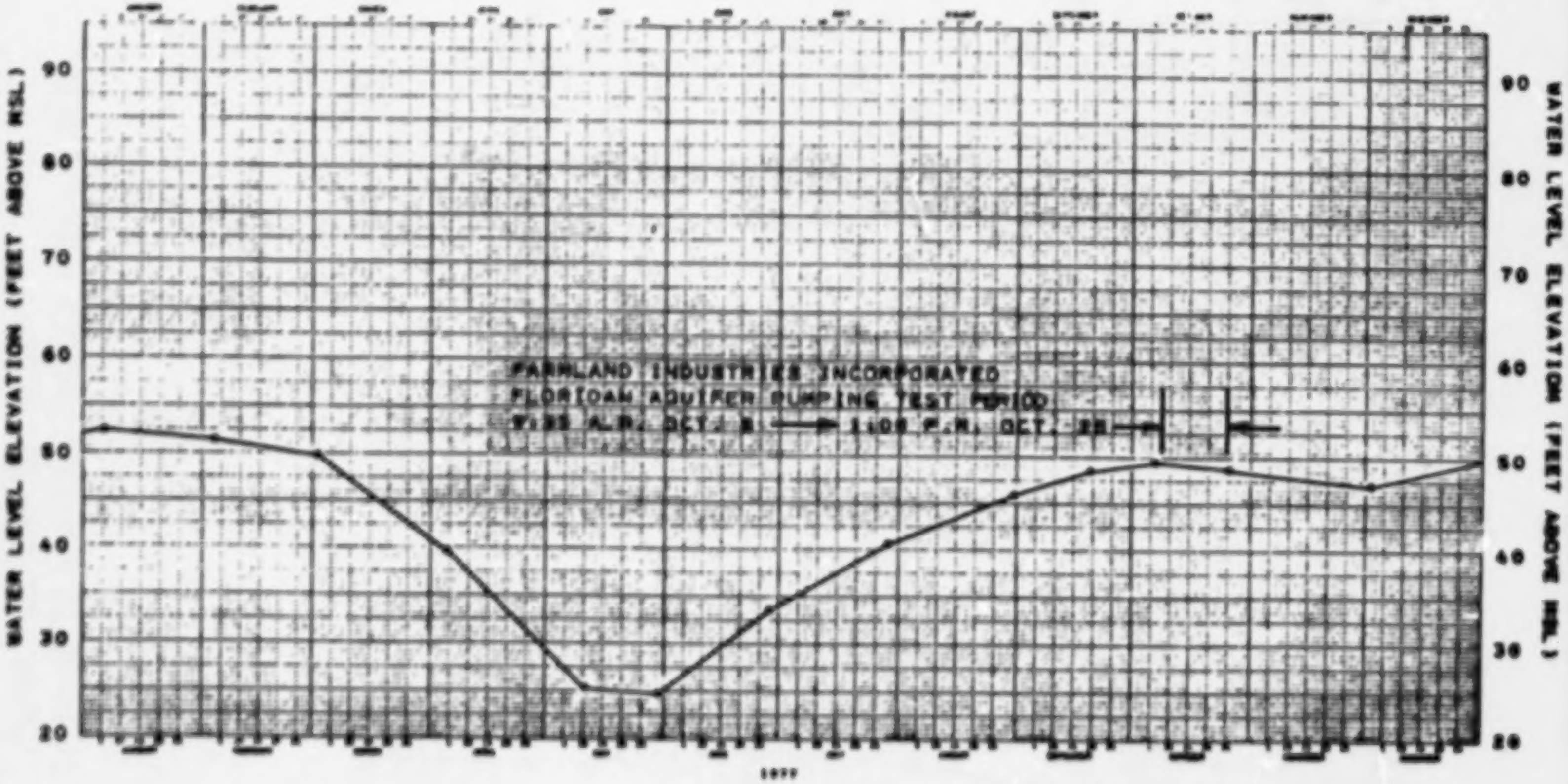

WAUCHULA
FDOW-7
FDOW-1
FDOW-2
TEST SITE
FDOW-3
FDOW-4
SWFWMD-2
SWFWMD-1
FDOW-5
FDOW-6
PROPERTY BOUNDARY
0
2 MILES

FIGURE 6-16. SELECTED WELLS MONITORED WITHIN 5-MILE RADIUS OF FARMLAND PUMPING TEST SITE.

SOURCE: P.E. LaMOREAUX & ASSOCIATES, INC., SUPPORTING REPORT FOR FARMLAND INDUSTRIES, INC., CONSUMPTIVE USE PERMIT, APRIL 1979



EXPLANATION
WELL NO: 273040081541901
LOCATION: NW¼ NW¼ SEC. 22, T.34S., R.24E.

FIGURE 6-17. HYDROGRAPH OF REGIONAL U.S.G.S. OBSERVATION WELL FOR 1977.

SOURCE: P.E. LaMOREAUX & ASSOCIATES, INC., SUPPORTING REPORT FOR FARMLAND INDUSTRIES, INC., CONSUMPTIVE USE PERMIT, APRIL 1979 site than at the Farmland site. The average storativity values for each site are similar. While leakage was measured at the Farmland site, no leakage was detected from the MCC test pumping data.

WELL INVENTORY

An inventory of water wells in the region of the property has been completed (PELA 1979a). The data from this inventory are found in Tables 6-4 and 6-5.

RECHARGE

The Surficial Aquifer is present at the land surface and is recharged by the direct percolation of rainfall. The Secondary Artesian Aquifer and the Floridan Aquifer do not crop out in the vicinity of the mine site. The nearest outcrop of these aquifers is in Citrus and Levy Counties, more than 100 miles north of the mine site. Thus, in the area of the proposed mine, any recharge to these aquifers is from leakage.

The water table elevation in the Surficial Aquifer is higher than the piezometer head in the lower aquifers. The head difference between the Surficial Aquifer and underlying Secondary Artesian and Floridan Aquifers reaches a maximum of 40 feet in May and remains relatively constant at 25 feet for 8 months of the year. These head differences are for a ground surface elevation of about 80 feet (MSL). Since the Surficial Aquifer water level generally follows the topography, the head difference will also vary with ground surface elevation. Due to this head difference, the Farmland property is an area of recharge from the Surficial Aquifer to the underlying artesian aquifers.

6.1.2 GROUNDWATER QUALITY

REGIONAL DESCRIPTION

Variations in groundwater quality occur over the site region, with agriculture, mining, chemical processing, and the overpumping of public-supply wells resulting in local degradation through contamination. An overview of groundwater quality in the site region has been compiled by EPA (1978a). Data are presented on the Surficial (Water Table*) Aquifer and Floridan Aquifer, the latter sometimes subdivided into the Upper Floridan (Secondary Artesian*) and Lower Floridan Aquifers. Summarizations from this overview are presented in the following paragraphs.

Surficial Aquifer

The dissolved solids content of the Surficial Aquifer varies from soft (less than 100 milligrams/liter) in inland areas to more than 250 milligrams/liter in shoreline areas. Contaminants found locally in Surficial Aquifer waters are: (1) saline waters which have migrated inward because of channelization and drainage in coastal areas; (2) nutrients from fertilized agricultural land; (3) leakage from sewers; (4) seepage from industrial lagoons; and (5) landfills.

Floridan Aquifer

The Floridan Aquifer is an extensive freshwater aquifer underlain by highly mineralized nonpotable water. Wells in the Floridan Aquifer at inland locations usually produce water meeting the U.S. Public Health Service's limits for drinking water supplies and the U.S. EPA's Interim Drinking Water Standards, while those in coastal areas from Tampa Bay to Charlotte Harbor yield no potable water (Figure 6-18). The Floridan Aquifer is, however, the drinking water source for about 91 percent of

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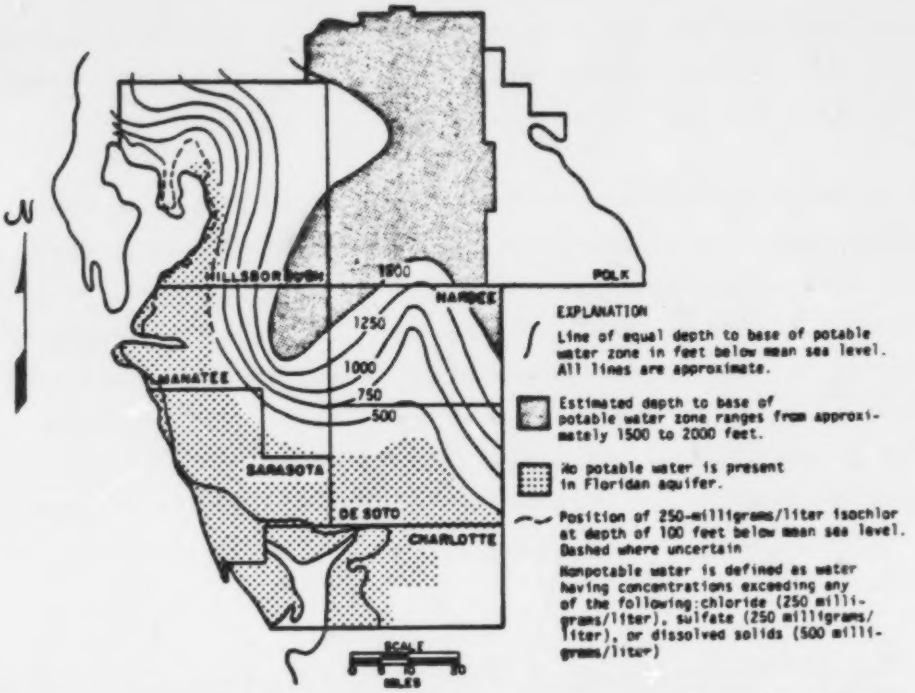
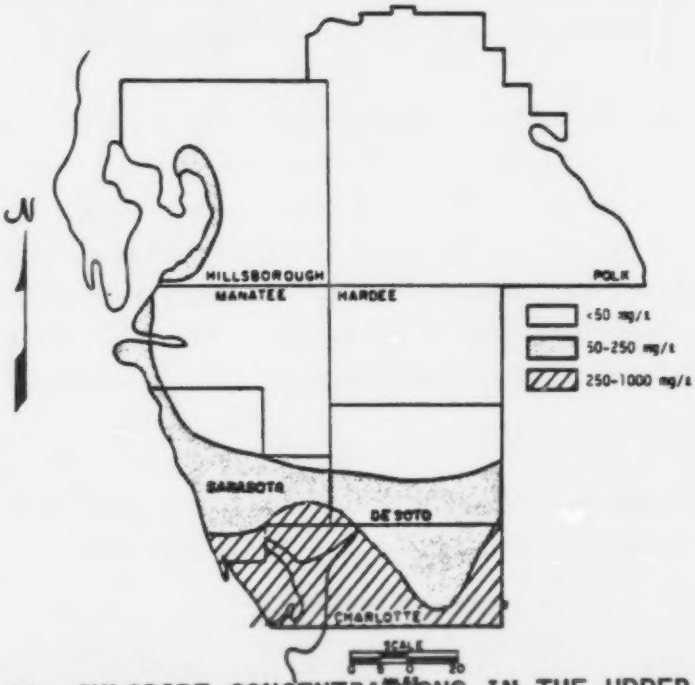
*Terms in parentheses are interchangeable with those which precede them.



HILLSBOROUGH
POLK
HARDEE
MANATEE
SARASOTA
DE SOTO
CHARLOTTE
1500
1250
1000
750
500
EXPLANATION
Line of equal depth to base of potable water zone in feet below mean sea level. All lines are approximate.
Estimated depth to base of potable water zone ranges from approximately 1500 to 2000 feet.
No potable water is present in Floridan aquifer.
Position of 250-milligrams/liter isochlor at depth of 100 feet below mean sea level. Dashed where uncertain
Nonpotable water is defined as water having concentrations exceeding any of the following: chloride (250 milligrams/liter), sulfate (250 milligrams/liter), or dissolved solids (500 milligrams/liter)
SCALE
MILES

FIGURE 6-18. DEPTH TO BASE OF POTABLE WATER ZONE IN FLORIDAN AQUIFER, 1975.



HILLSBOROUGH
POLK
MANATEE
HARDEE
SARASOTA
DE SOTO
CHARLOTTE
<50 mg/ℓ
50-250 mg/ℓ
250-1000 mg/ℓ
SCALE

FIGURE 6-19. CHLORIDE CONCENTRATIONS IN THE UPPER FLORIDAN AQUIFER

SOURCE: U.S. ENVIRONMENTAL PROTECTION AGENCY, CENTRAL FLORIDA PHOSPHATE INDUSTRY AREAWIDE IMPACT ASSESSMENT PROGRAM, VOLUME V: WATER, SEPTEMBER 1978.

Florida's population. It also represents a major portion of the baseflow of many Florida streams, and may be 100 percent of the streamflow during the winter dry season.

Saltwater intrusion is of most concern in coastal areas where drainage canals and other tidal channels, as well as pumping near the coast, have reduced the potentiometric head. This has resulted in the landward migration of the saltwater wedge. Inland saltwater contamination of Floridan Aquifer water occurs largely from the pumping of aquifer water for irrigation. When high-chloride water is applied in excess of crop need, it percolates into the water table aquifer resulting in contamination at more remote points. Figure 6-19 presents the chloride concentrations in the Upper Floridan Aquifer over the site region.

Sulfate is also present in Floridan Aquifer water. The highest concentrations occur in coastal areas (because of influence of salt water from the ocean) and in the deeper zones within the aquifer. The concentrations reported in water from the Secondary Artesian (Upper Floridan) Aquifer over the site region are provided in Figure 6-20.

Dissolved solids within the Floridan Aquifer in the site region are calcium and carbonate. In coastal areas, including most of Sarasota County, sodium and chloride are the predominant constituents. Highly mineralized water occurs throughout Charlotte and Sarasota Counties, in western Manatee County, and southwestern Hillsborough County. The concentrations of dissolved solids found in water from the Secondary Artesian (Upper Floridan) Aquifer over the site region are provided in Figure 6-21.

The concentrations of radium-226 in groundwater in west central Florida have also been researched by the U.S. EPA. The study considered

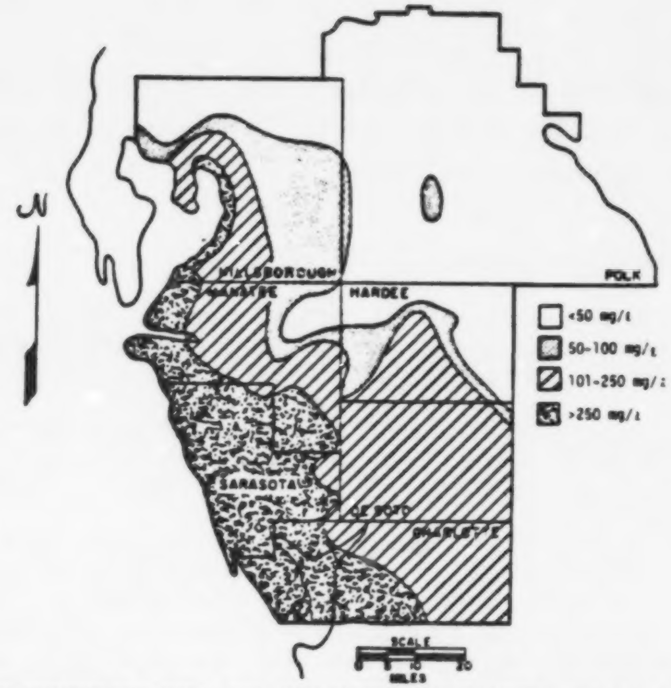

N
HILLSBOROUGH
POLK
MANATEE
HARDEE
SARASOTA
DE SOTO
CHARLOTTE
☐ <50 mg/l
▨ 50-100 mg/l
▨ 101-250 mg/l
▨ >250 mg/l
SCALE
0 5 10 20
MILES

FIGURE 6-20. CONCENTRATIONS OF SULFATE IN WATER FROM THE UPPER FLORIDAN AQUIFER.

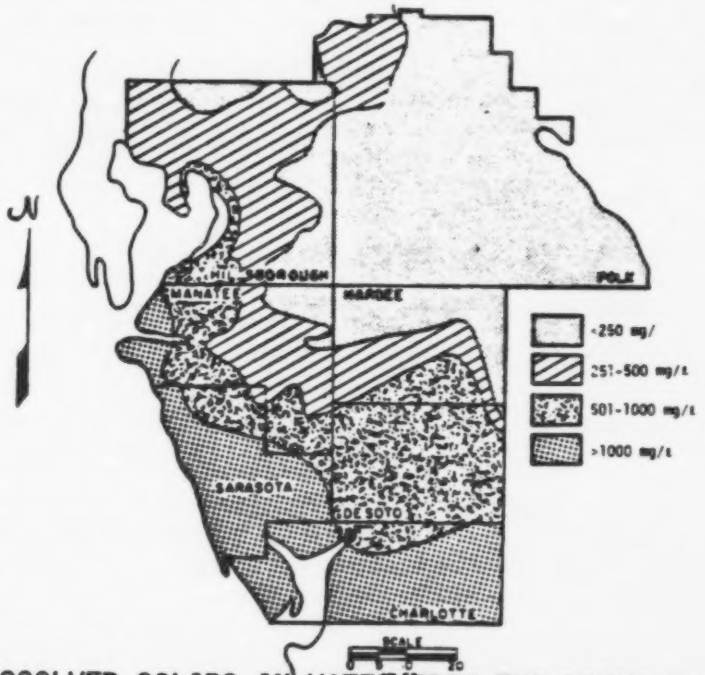

N
HILLSBOROUGH
POLK
MANATEE
HARDEE
SARASOTA
DE SOTO
CHARLOTTE
☐ <250 mg/
▨ 251-500 mg/l
▨ 501-1000 mg/l
▨ >1000 mg/l
SCALE
0 5 10 20

FIGURE 6-21. DISSOLVED SOLIDS IN WATER FROM THE UPPER FLORIDAN AQUIFER.

SOURCE: U.S. ENVIRONMENTAL PROTECTION AGENCY, CENTRAL FLORIDA PHOSPHATE INDUSTRY AREAWIDE IMPACT ASSESSMENT PROGRAM, VOLUME V: WATER, SEPTEMBER 1978.

two areas: (1) Polk, Hardee, Hillsborough, DeSoto, and Manatee Counties; and (2) Sarasota County. The following summary of the results of study are as reported by EPA (1978a):

- Water-table aquifer
    - The geometric mean of radium concentration in unmined mineralized areas was 0.17 picocuries per liter; in mined areas, 0.55 picocuries per liter.
    - Dissolved radium (Ra-226) assessment by Mann-Whitney U-test (α=0.05) indicated no significant difference between areas impacted by mining and mineralized but unmined areas.
    - None of the Ra-226 concentrations in mined areas exceeded 5 picocuries per liter (the EPA drinking water standard for combined Ra-226 and Ra-228 concentration is 5.0 pci/l). Conformance with this standard cannot be determined from the available data, as concurrent Ra-228 analyses were not performed.
- Upper Floridan aquifer
    - Ra-226 concentrations averaged as high or higher in nonmineralized areas as in mineralized unmined or mined areas.
    - Dissolved Ra-226 assessment by the Kruskal-Wallis test (α=0.05) indicated significant differences between nonmineralized, mineralized, unmined, and mined areas; and the nonmineralized areas displayed higher Ra-226 concentrations than the mined areas.
    - Average Ra-226 concentrations were higher than those in the water-table aquifer and similar to those in the lower Floridan aquifer.
- Lower Floridan aquifer
    - Ra-226 concentrations averaged as high or higher in nonmineralized areas as in mineralized unmined or mined areas.
    - Ra-226 concentrations were not significantly different (Mann-Whitney U-test, α=0.05) in nonmineralized and mineralized unmined and mined areas.

For Sarasota County (Area 2) the following was reported:

- Ra-226 concentrations were 100 times higher in the water-table aquifer and almost 10 times higher in the upper and lower Floridan aquifers than in study area 1.
- Ra-226 concentrations in the water-table aquifer in the coastal area were significantly greater (Mann-Whitney U-test, $\alpha=0.05$) than in the inland area.
- Higher-than-average (relative to Florida and U.S.) Ra-226 concentrations in both the water-table and Floridan aquifers are attributed to natural enrichment (probably related to radium-enriched, mineralized groundwater that is deep beneath the central Florida peninsula and shallow in the coastal areas) and to dissolution of Ra-226 from the Hawthorn formation (which is very near the land surface in western Sarasota County).

For both Area 1 and Area 2, the following was reported:

- A detrimental effect by phosphate mining on Ra-226 in the upper Floridan aquifer is not documented. Existing radium data do not substantiate previously alleged widespread radium contamination of groundwater by the phosphate industry. Natural variability in the radium content of groundwater complicates determination of background versus contaminated conditions and underscores the need for more intensive data collection as an integral part of water and land management.
- Ra-226 data collected from the water-table, upper Floridan, and lower Floridan aquifers in 1966 by the Federal Water Pollution Control Administration and in 1974-76 by the U.S. Geological Survey revealed no statistically significant (Kruskal-Wallis test, $\alpha=0.05$) difference for the decade interval (1966-76).
- Hydrogeologic conditions favor entrance of contaminants to at least the water-table and upper Floridan aquifers, but contamination is generally poorly documented due in part to monitoring deficiencies. Potential contaminant sources include high dissolved radium in gypsum-pond water and suspended radium in slime ponds. Contaminants can enter groundwater because of sinkhole collapse (or similar release) and seepage; especially does the siting of waste-disposal facilities in contact with limestone strata of the Hawthorn formation foster contamination. Incidence of local contamination

(laterally to distances of a mile or less and to depths of several hundred feet or less) is likely to continue as water use and mining expand. Additional industry-sponsored monitoring of shallow aquifers is warranted--particularly industry participation in cooperative state and federal studies of long-term water quality changes in the lower Floridan aquifer as a result of water withdrawal and dewatering.

- Hydrogeologic conditions in the area of phosphate mineralization are quite variable (principally in the distribution and permeability of carbonate strata in the Hawthorn formation and the degree of interconnection between the upper and lower Floridan aquifers) and can be favorable or unfavorable for waste disposal. Disposal of acidic chemical processing effluent may induce solution and collapse of carbonate strata and thereby increase contamination, but the data to support the widespread occurrence of this phenomenon are scanty and the environmental impact of the industry needs additional definition via specific studies.

- The radiochemical quality of water introduced to the lower Floridan aquifer via recharge wells has only recently begun to be documented. Preliminary data from the SWFWMD indicate that radium-226 levels are generally lower than those in the lower Floridan aquifer. The occurrence of at least locally high natural concentrations of radium in the shallower aquifers requires close monitoring and site-specific documentation.

EPA (1978a) also present a discussion of groundwater quality by county. The following is taken from this presentation for Hardee and DeSoto Counties:

> The water-table aquifer in Hardee and DeSoto Counties is tapped at a depth of 40 to 65 feet and is generally believed to increase in thickness from north to south. Many of the wells used for domestic purposes or for lawn-watering or stock-watering tap the water-table aquifer.
>
> The most productive and widely used aquifer in the two counties is the Floridan aquifer. It provides the public water supply for the City of Arcadia.
>
> Within the Floridan aquifer, dissolved-solids concentrations generally increase from northern Hardee County toward southern DeSoto County and also increase with depth. Concentrations exceeding 500 milligrams per liter occur in the upper part of the

aquifer in southeastern and southwestern DeSoto County, in the lower Floridan aquifer, along the Peace River, in the southern part of Hardee County, and in all of DeSoto County. The water temperature generally increases from northern Hardee to southwestern DeSoto County, as well as with depth. The water underlying Hardee and DeSoto Counties is generally hard because of the predominance of calcium- and magnesium-rich limestone and dolomite in the matrix. Generally, water from the upper part of the Floridan aquifer is moderately hard to hard (61 to 180 milligrams per liter) in northern Hardee County, increasing in hardness toward southern DeSoto County where the water is very hard (exceeding 500 milligrams per liter). Within the lower part of the Floridan aquifer, the only moderately hard to hard water occurs in the northeast corner of Hardee County, with hardness increasing toward the southwest.

Sulfate concentrations in Hardee and DeSoto Counties generally increase with depth. Most is probably derived from the solution of gypsum and anhydrite (calcium-sulfate minerals) found in the lower Floridan aquifer. In the upper Floridan, concentrations generally increase from north Hardee to southwest DeSoto. Southwest of Arcadia, concentrations range from 100 to more than 250 milligrams per liter. Only in the northern half of Hardee County does water from the lower Floridan contain less than 100 milligrams per liter of sulfate. A zone exhibiting more than 250 milligrams per liter extends across southernmost Hardee County, northern DeSoto County, and southwater along the Peace River valley, with the water in most of southern DeSoto County containing less sulfate (101-250 milligrams per liter).

Chloride concentrations in the Florida aquifer in Hardee and DeSoto Counties generally are less than 50 milligrams per liter although in areas south of Arcadia they range from 50 to 250 milligrams per liter and near the southwest Sarasota-DeSoto County line exceed 250 milligrams per liter. Concentrations of fluoride in the Floridan aquifer underlying the two counties form a concentric pattern, increasing toward the center. In both the upper and lower Floridan aquifers, concentrations are 0.8 milligrams per liter or less only along the periphery of Hardee and DeSoto Counties (except along the western boundary where concentrations are higher). In much of the central area along the Hardee-DeSoto County line, aquifer concentrations in the upper Floridan exceed 1.4 milligrams per liter (and some exceed 2.0 milligrams per liter). In the lower Floridan, concentrations exceeding 1.4 milligrams per liter are restricted to western DeSoto County. The principal source of fluoride in Hardee and DeSoto Counties is fluorapatite, a mineral restricted to rocks of the upper Floridan aquifer and younger deposits. Fluorapatite is the principal source mineral of phosphate in the land-pebble mining district of central Florida.

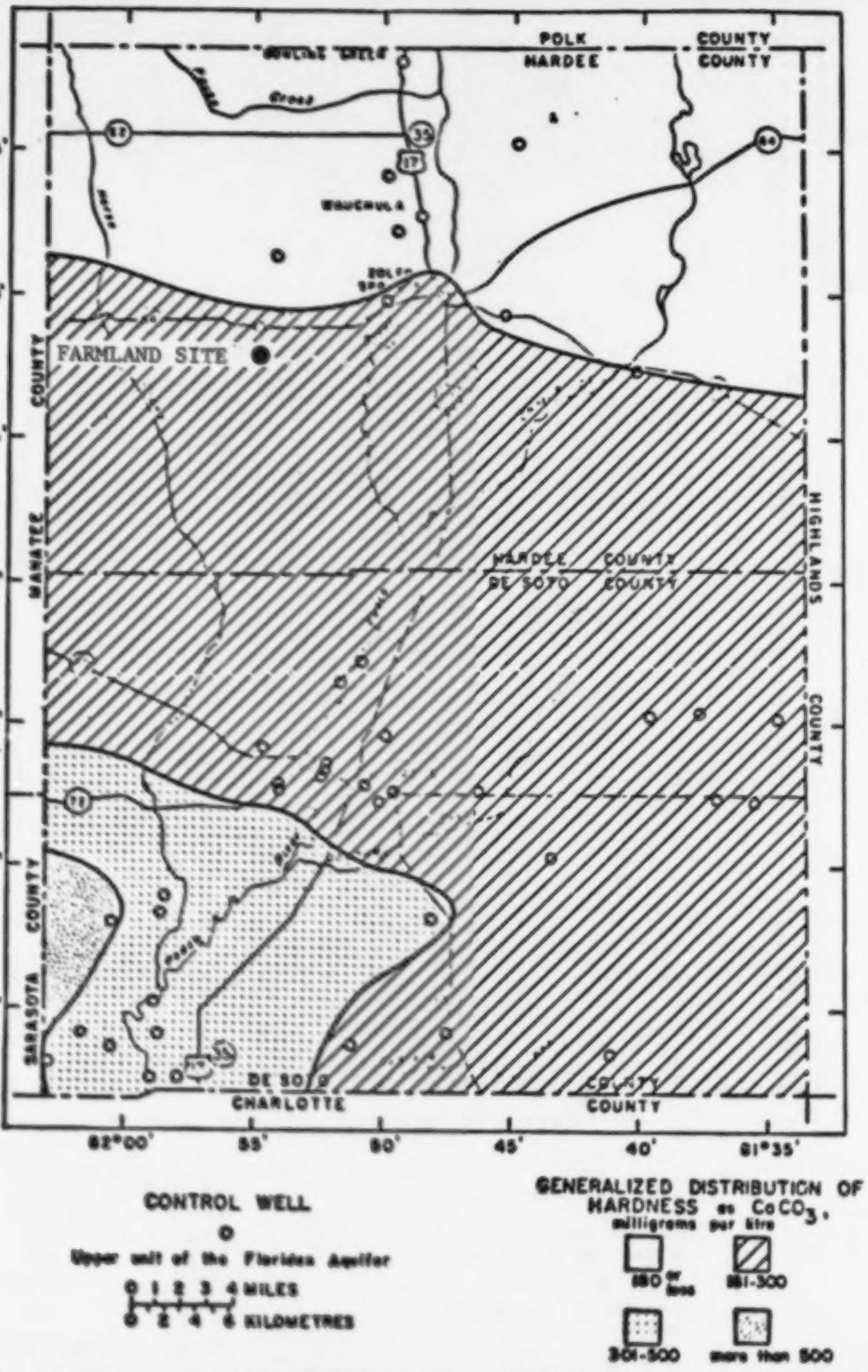
The distribution of hardness, fluoride, dissolved solids and sulfate in the upper and/or lower units of the Floridan Aquifer over the Hardee-DeSoto County area are given in Figures 6-22, 6-23, 6-24, 6-25, 6-26, and 6-27.

SITE STUDIES

This section presents a discussion of the existing groundwater quality data for the three primary aquifer systems that underlie the Farmland site. The chemical composition of the groundwaters underlying the site depends on several factors. These factors include the source of the water, its movement and the soil and rock through which the water moves. The latter factor, the soil/rock matrix, has the greatest effect and as a result, changes in groundwater quality can frequently be traced to changes in the chemical composition of the sediments that comprising the aquifer in question.

Sampling Program

The groundwater quality data that have been obtained from the project site were collected in three phases. During the period (PELA 1978) which extended from June 1977 to July 1978, the waters of the Surficial Aquifer were monitored on a monthly basis at 10 wells located on the Farmland property (Tables B-1 thru B-10 in Appendix B). In addition, the Secondary Artesian Aquifer was sampled twice in July 1977, and the Floridan Aquifer was sampled four times in October 1977 (Table B-11). The samples collected were analyzed for the following constituents: temperature, pH, conductivity, solids (dissolved and suspended), alkalinity, hardness, the major cations and anions, hydrogen sulfide, nitrate, phosphate, radium-226, and gross alpha. On October 19, 1979, a special trace element analysis was performed on samples from wells FIF-1, FIS-3, PT-1, and PT-2 (Table B-12). On Figure 6-28, surficial wells have either a FP or PT prefix; FIS and FIS designations correspond to Secondary Artesian and Floridan wells, respectively. All sampling and analyses for these efforts were done for Farmland by PELA.



POLK COUNTY
HARDEE COUNTY
Bowling Green
Peace
Creek
62
35
17
64
WAUCHULA
ZOLFO SPRINGS
FARMLAND SITE
MANATEE COUNTY
HIGHLANDS COUNTY
HARDEE COUNTY
DE SOTO COUNTY
72
SARASOTA COUNTY
DE SOTO COUNTY
CHARLOTTE COUNTY
27°35'
30'
25'
20'
15'
10'
27°05'
82°00'
55'
50'
45'
40'
81°35'
CONTROL WELL
○
Upper unit of the Floridan Aquifer
0 1 2 3 4 MILES
0 2 4 6 KILOMETRES
GENERALIZED DISTRIBUTION OF HARDNESS as $CaCO_3$, milligrams per litre
180 or less
181-300
301-500
more than 500

FIGURE G-22. GENERALIZED DISTRIBUTION OF HARDNESS IN THE UPPER UNIT OF THE FLORIDAN AQUIFER.

SOURCE: ADLEY ASSOCIATES, INC., NATURAL RESOURCE FACTORS, COMPREHENSIVE PLAN, HARDEE COUNTY, FLORIDA. 1979.

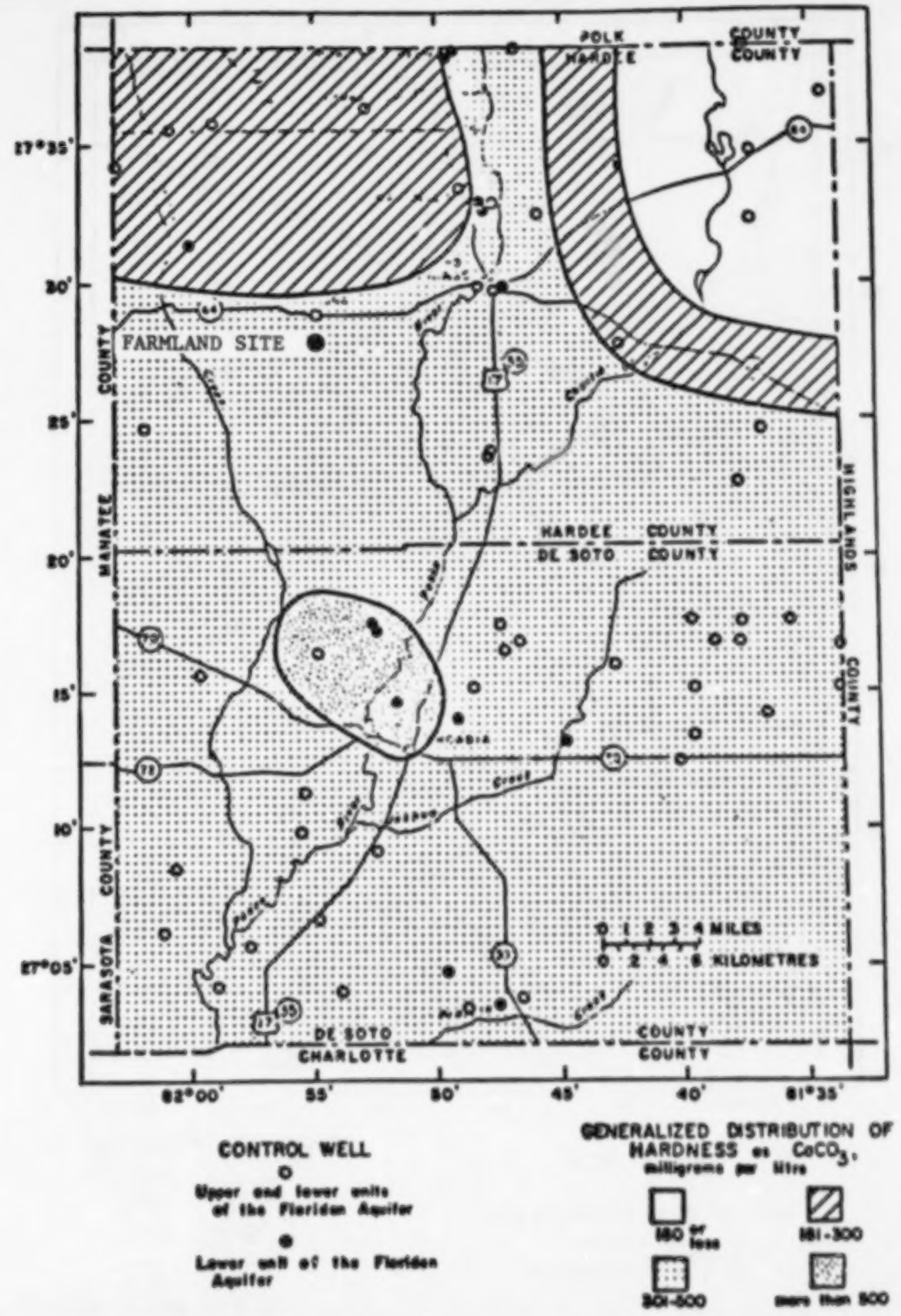
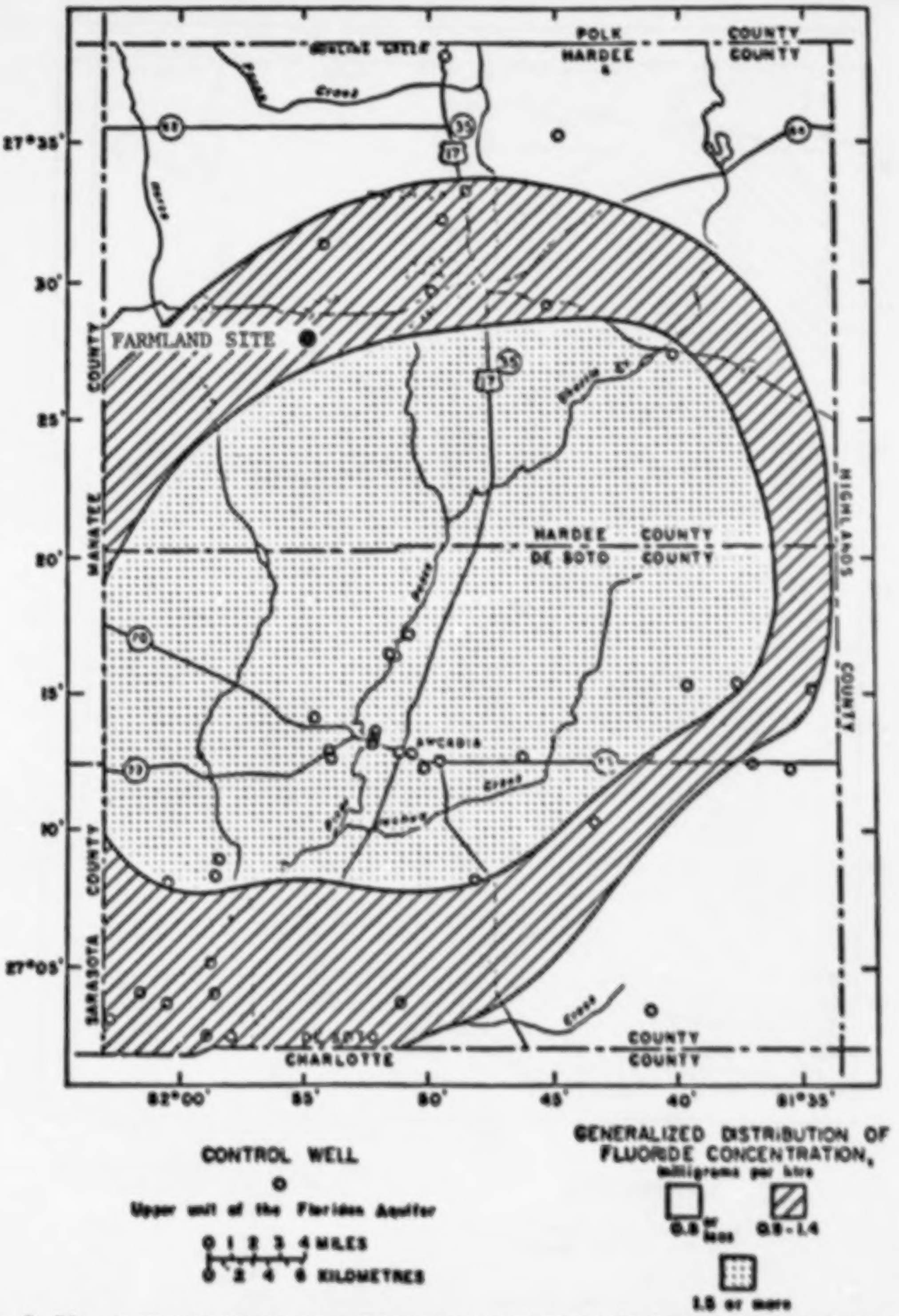

POLK COUNTY
HARDEE COUNTY
FARMLAND SITE
MANATEE COUNTY
HARDEE COUNTY
DE SOTO COUNTY
HIGHLANDS COUNTY
SARASOTA COUNTY
DE SOTO COUNTY
CHARLOTTE COUNTY
ARCADIA
27°35'
30'
25'
20'
15'
10'
27°05'
82°00'
55'
50'
45'
40'
81°35'
0 1 2 3 4 MILES
0 2 4 6 KILOMETRES
CONTROL WELL
○ Upper and lower units of the Floridan Aquifer
● Lower unit of the Floridan Aquifer
GENERALIZED DISTRIBUTION OF HARDNESS as CaCO3, milligrams per litre
180 or less
181-300
301-500
more than 500

FIGURE 6-23. GENERALIZED DISTRIBUTION OF HARDNESS IN THE LOWER UNIT OF THE FLORIDAN AQUIFER.

SOURCE: ADLEY ASSOCIATES, INC., NATURAL RESOURCE FACTORS, COMPREHENSIVE PLAN, HARDEE COUNTY, FLORIDA 1979.



POLK
HARDEE
COUNTY
COUNTY
FARMLAND SITE
MANATEE COUNTY
HARDEE COUNTY
DE SOTO COUNTY
HIGHLANDS COUNTY
SARASOTA COUNTY
CHARLOTTE COUNTY
ARCADIA
27°35'
30'
25'
20'
15'
10'
27°05'
82°00'
55'
50'
45'
40'
81°35'
CONTROL WELL
Upper unit of the Floridan Aquifer
0 1 2 3 4 MILES
0 2 4 6 KILOMETRES
GENERALIZED DISTRIBUTION OF FLUORIDE CONCENTRATION, milligrams per litre
0.8 or less
0.8-1.4
1.5 or more

FIGURE 6-24. GENERALIZED DISTRIBUTION OF FLUORIDES IN THE UPPER UNIT OF THE FLORIDAN AQUIFER.

SOURCE: ADLEY ASSOCIATES, INC., NATURAL RESOURCE FACTORS, COMPREHENSIVE PLAN, HARDEE COUNTY, FLORIDA. 1979.

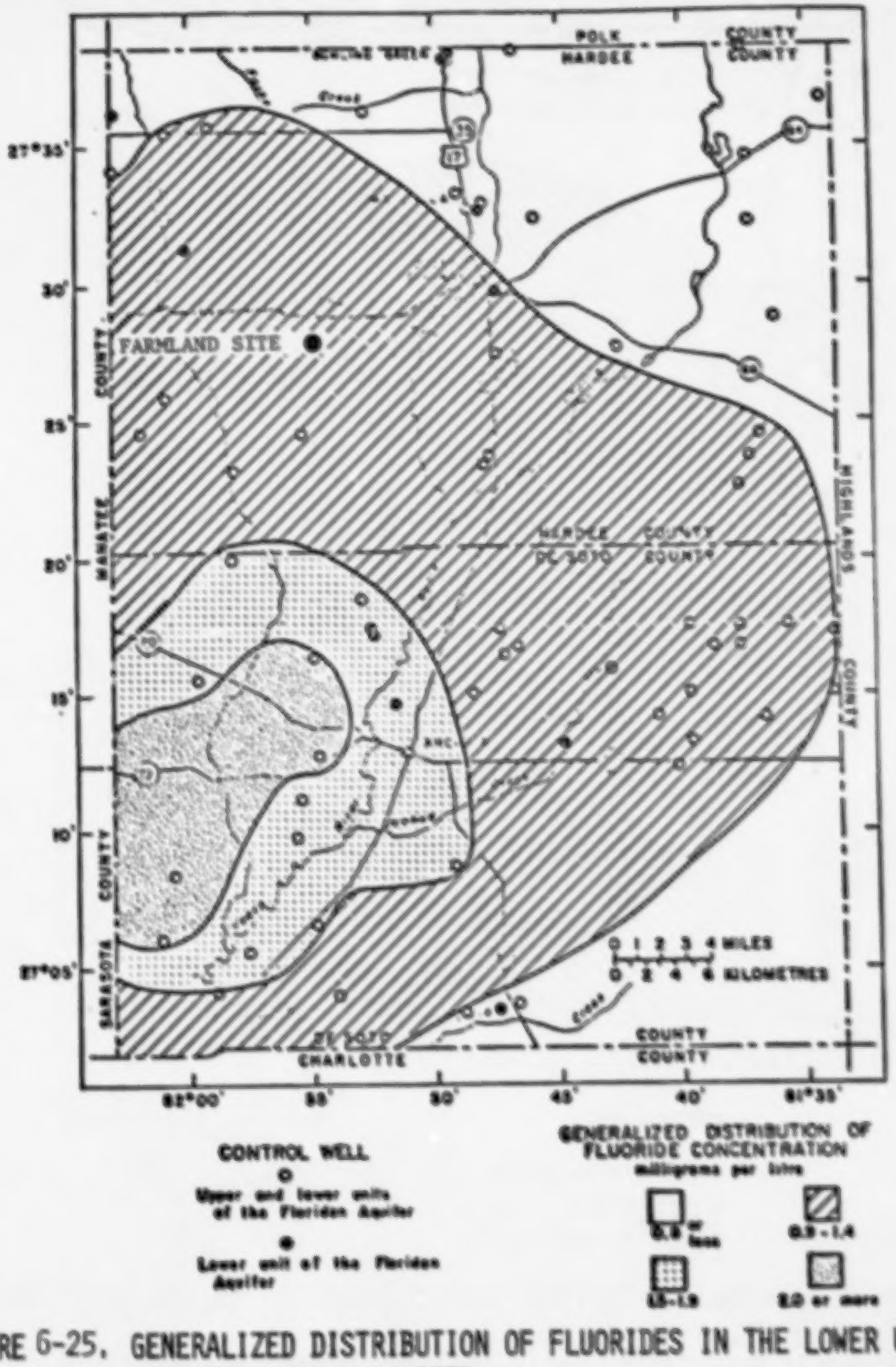

POLK COUNTY
HARDEE COUNTY
BOWLING GREEN
FARMLAND SITE
MANATEE COUNTY
HIGHLANDS COUNTY
HARDEE COUNTY
DE SOTO COUNTY
SARASOTA COUNTY
DE SOTO COUNTY
CHARLOTTE COUNTY
27°35'
30'
25'
20'
15'
10'
27°05'
82°00'
55'
50'
45'
40'
81°35'
0 1 2 3 4 MILES
0 2 4 6 KILOMETRES
CONTROL WELL
Upper and lower units of the Floridan Aquifer
Lower unit of the Floridan Aquifer
GENERALIZED DISTRIBUTION OF FLUORIDE CONCENTRATION
milligrams per litre
0.8 or less
0.9 - 1.4
1.5-1.9
2.0 or more

FIGURE 6-25. GENERALIZED DISTRIBUTION OF FLUORIDES IN THE LOWER UNIT OF THE FLORIDAN AQUIFER.

SOURCE: ADLEY ASSOCIATES, INC., NATURAL RESOURCE FACTORS, COMPREHENSIVE PLAN, HARDEE COUNTY, FLORIDA 1979.

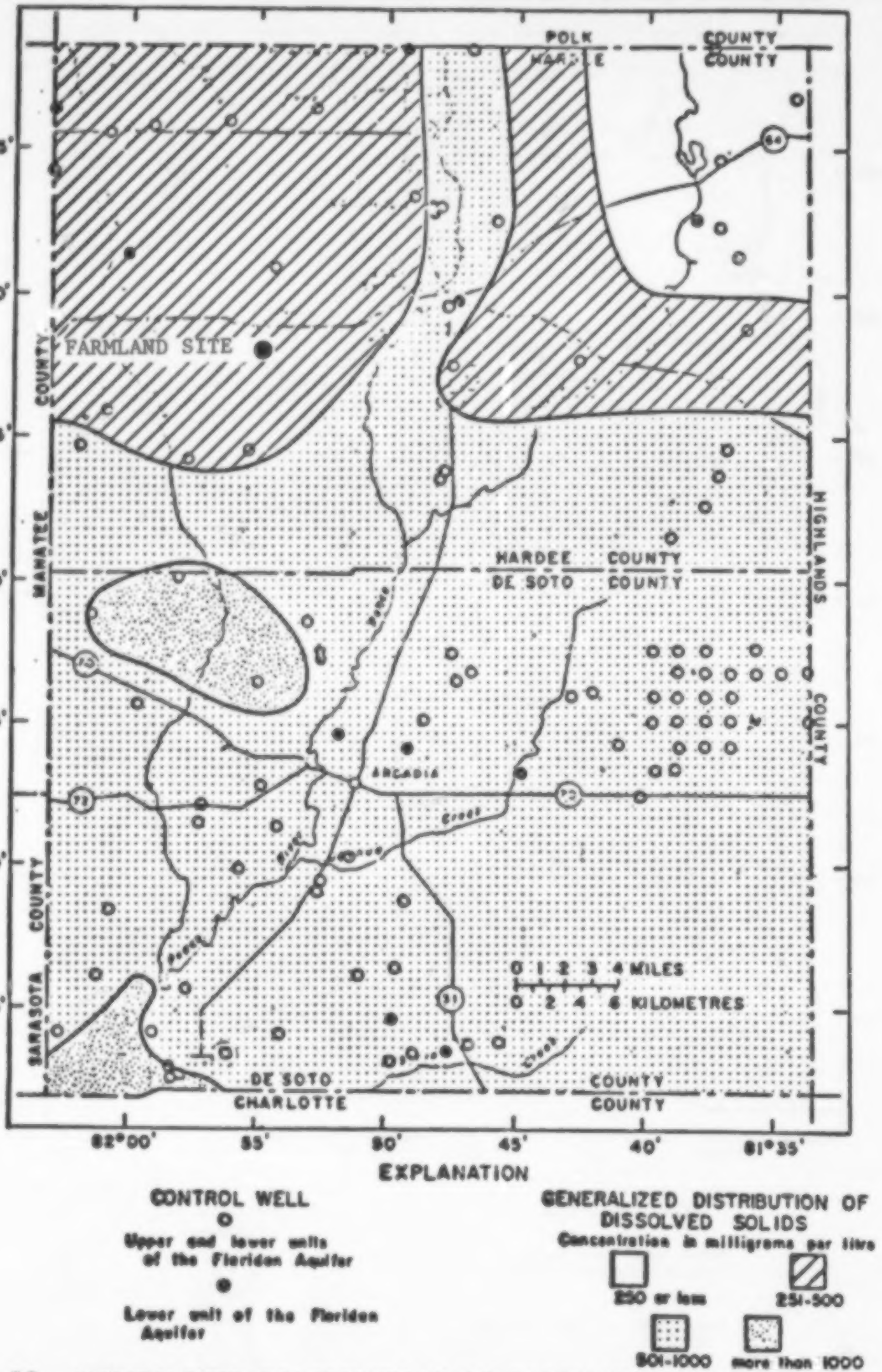

POLK COUNTY
HARDEE COUNTY
27°35'
30'
25'
20'
15'
10'
27°05'
FARMLAND SITE
MANATEE COUNTY
HARDEE COUNTY
DE SOTO COUNTY
HIGHLANDS COUNTY
ARCADIA
Peace River
SARASOTA COUNTY
0 1 2 3 4 MILES
0 2 4 6 KILOMETRES
DE SOTO COUNTY
CHARLOTTE COUNTY
82°00'
55'
50'
45'
40'
81°35'
EXPLANATION
CONTROL WELL
○ Upper and lower units of the Floridan Aquifer
● Lower unit of the Floridan Aquifer
GENERALIZED DISTRIBUTION OF DISSOLVED SOLIDS
Concentration in milligrams per litre
250 or less
251-500
501-1000
more than 1000

FIGURE 6-26. GENERALIZED DISTRIBUTION OF DISSOLVED SOLIDS IN THE LOWER UNIT OF THE FLORIDAN AQUIFER.

SOURCE: ADLEY ASSOCIATES, INC., NATURAL RESOURCE FACTORS, COMPREHENSIVE PLAN, HARDEE COUNTY, FLORIDA, 1979.

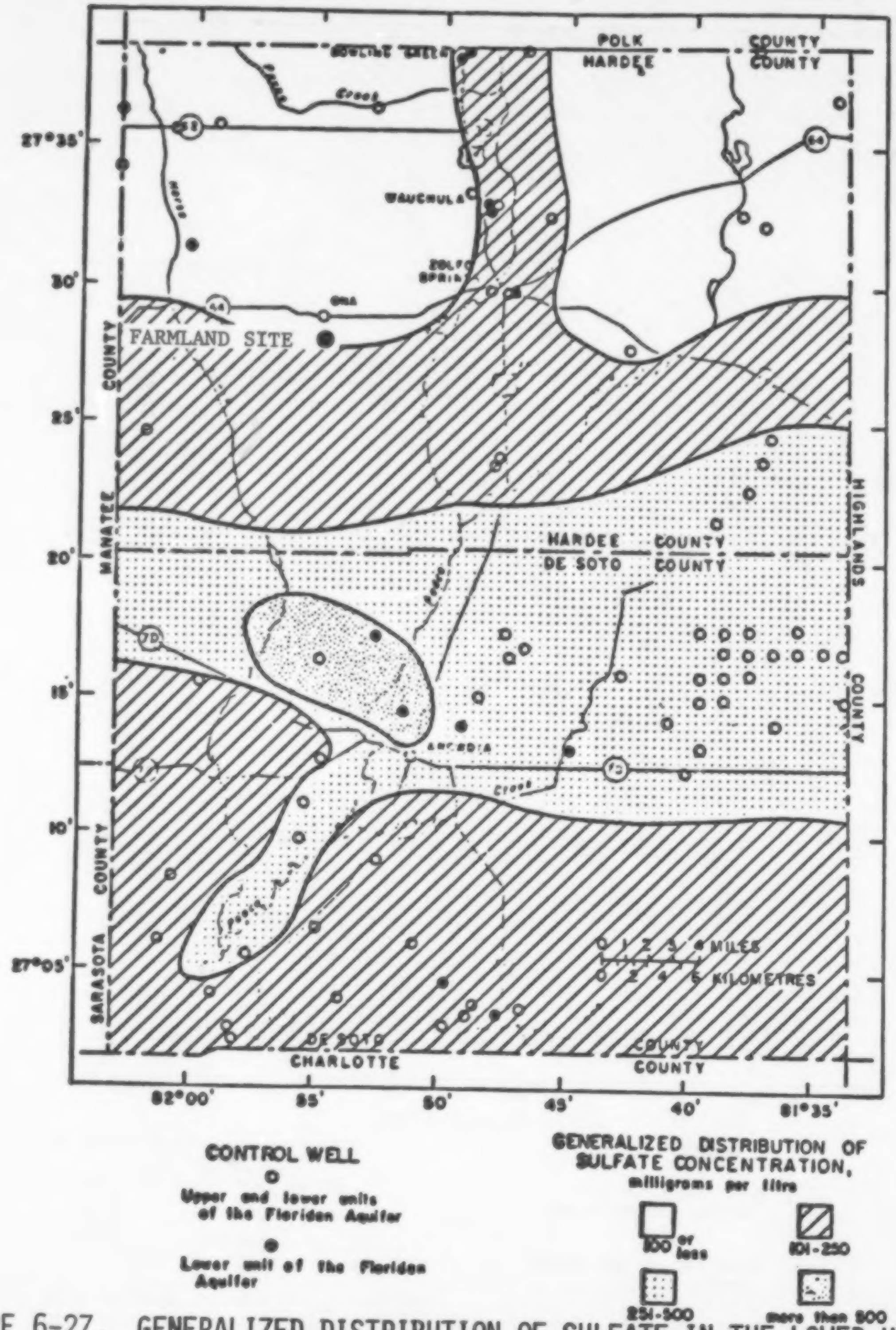

POLK COUNTY
HARDEE COUNTY
BOWLING GREEN
WAUCHULA
ZOLFO SPRINGS
ONA
FARMLAND SITE
MANATEE COUNTY
HARDEE COUNTY
DE SOTO COUNTY
HIGHLANDS COUNTY
ARCADIA
SARASOTA COUNTY
DE SOTO COUNTY
CHARLOTTE COUNTY
27°35'
30'
25'
20'
15'
10'
27°05'
82°00'
55'
50'
45'
40'
81°35'
0 1 2 3 4 MILES
0 2 4 6 KILOMETRES
CONTROL WELL
○ Upper and lower units of the Floridan Aquifer
● Lower unit of the Floridan Aquifer
GENERALIZED DISTRIBUTION OF SULFATE CONCENTRATION, milligrams per litre
☐ 100 or less
▨ 101-250
⬚ 251-500
▩ more than 500

FIGURE 6-27. GENERALIZED DISTRIBUTION OF SULFATE IN THE LOWER UNIT OF THE FLORIDAN AQUIFER.

SOURCE: ADLEY ASSOCIATES, INC., NATURAL RESOURCE FACTORS, COMPREHENSIVE PLAN, HARDEE COUNTY, FLORIDA. 1979.

An additional effort involved the collection of samples in October 1979 and March 1980 by WCC from selected wells in the Surficial, Secondary Artesian, and Floridan Aquifer (wells FIF-1, FIS-3, PT-1, and PT-2 on Figure 6-28). The October 1979 sampling was done as part of a split-sample analysis with PELA and included a broad list of parameters (Table 6-6). The March 1980 analyses were for a reduced number of parameters and with no split samples. All analyses of the WCC samples were done by Wilson Laboratories of Salina, Kansas. Results are presented in Table B-13.

Existing Water Quality

The quality of these underlying groundwaters is generally good, with only a few parameters exhibiting high enough concentrations to warrant concern from a public health standpoint. A discussion of the parameters that exceed applicable health standards is presented at the end of this section. Primarily because of the effects of local geology, the water in each of these three aquifer systems has a distinctive chemical character. Summarizations of pertinent data for each of these three groundwater horizons are presented in Tables 6-7 and 6-8.

The ionic strength of these groundwaters is generally low with levels in the Surficial Aquifer being typically less than 3.0 milliequivalents per liter, while the two underlying aquifers are in the 10.0 meq/l range. The dominant cation in the Surficial Aquifer is calcium, while both calcium and magnesium are present in significant levels in the Secondary Artesian and Floridan Aquifers. Bicarbonate is the primary anion in all three aquifers, although sulfate concentrations in the Floridan Aquifer are also significant.

The observed trend of increasing ionic strength and the associated increase of dissolved solids and conductivity with depth suggests merely that the deeper waters have been in contact with local geologic stratum longer, thereby dissolving more salts in the process. A corollary to

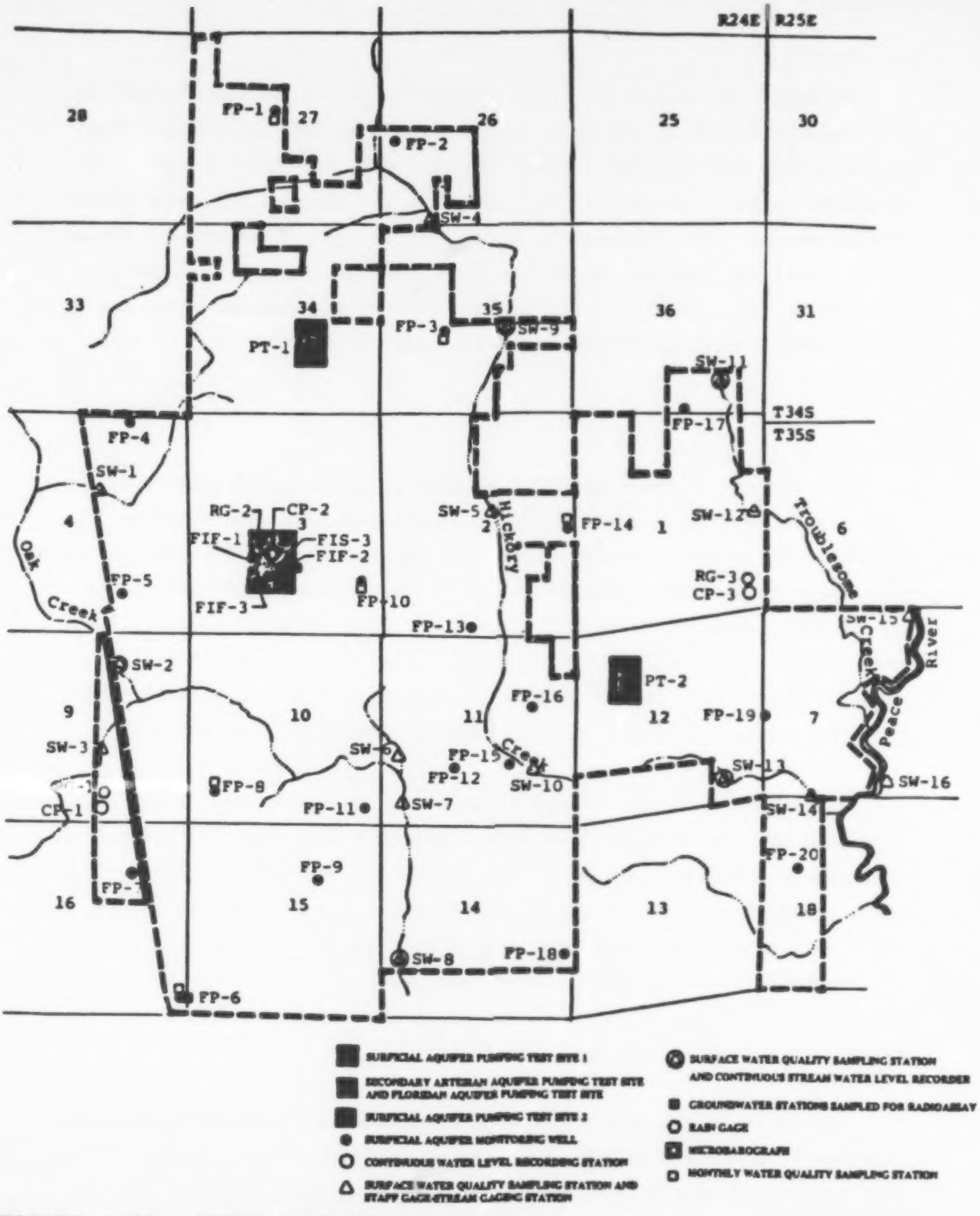

R24E
R25E
T34S
T35S
28
27
26
25
30
33
34
35
36
31
4
3
2
1
6
9
10
11
12
7
16
15
14
13
18
FP-1
FP-2
SW-4
PT-1
FP-3
SW-9
SW-11
FP-17
FP-4
SW-1
RG-2
CP-2
FIF-1
FIS-3
FIF-2
FIF-3
FP-5
Oak
Creek
FP-10
FP-13
SW-5
Hickory
FP-14
SW-12
Troublesome
RG-3
CP-3
SW-15
Creek
River
Peace
PT-2
FP-16
FP-19
SW-2
SW-3
CP-1
FP-8
FP-11
SW-6
SW-7
FP-15
FP-12
Creek
SW-10
SW-13
SW-16
SW-14
FP-20
FP-9
FP-7
FP-18
SW-8
FP-6
SURFICIAL AQUIFER PUMPING TEST SITE 1
SECONDARY ARTESIAN AQUIFER PUMPING TEST SITE AND FLORIDAN AQUIFER PUMPING TEST SITE
SURFICIAL AQUIFER PUMPING TEST SITE 2
SURFICIAL AQUIFER MONITORING WELL
CONTINUOUS WATER LEVEL RECORDING STATION
SURFACE WATER QUALITY SAMPLING STATION AND STAFF GAGE-STREAM GAGING STATION
SURFACE WATER QUALITY SAMPLING STATION AND CONTINUOUS STREAM WATER LEVEL RECORDER
GROUNDWATER STATIONS SAMPLED FOR RADIOASSAY
RAIN GAGE
MICROBAROGRAPH
MONTHLY WATER QUALITY SAMPLING STATION
N
0
2,000
4,000
SCALE IN FEET

FIGURE 6-28. WATER SAMPLING LOCATIONS

SOURCE: FARMLAND INDUSTRIES, INC., DRI, JUNE 1979

this trend is the observed increase in sulfate levels with depth, an occurrence that probably arises from the dissolution of evaporate sediments, gypsum, and anhydrite minerals occurring in the Ocala Group and the Avon Park Limestone. Similarly, the presence of higher calcium and magnesium levels and relatively low sodium chloride concentrations in the Floridan Aquifer suggest that the water in this aquifer is hydrologically separated from underlying deep saline aquifers by a relatively impermeable horizon.

Waters in the Surficial Aquifer, especially in the eastern portion of the project site, tend to be acidic (pH values average 5.5). In comparison, the waters of the two deeper aquifers are more neutral in character. This change in pH values plus the heightened levels of iron found in the Surficial Aquifer probably are related to similar levels found in the adjacent surface waters, which themselves arise from the leaching of tannic and other weak organic acids from decaying vegetative matter. These high iron and low pH values do not, however, constitute a significant threat to the two underlying aquifer systems, since the calcium carbonate levels in both are sufficient enough to quickly neutralize the lower pH levels and to precipitate out the iron.

Phosphate concentrations also decrease with depth, but in this case the cause arises from the nature of the aquifers and not from inputs of surficial waters. The high phosphate levels observed in the Surficial Aquifer can probably be traced to the presence of the phosphate-bearing ore body within this groundwater horizon. The two underlying aquifers are not in direct physical contact with this ore body and probably receive their recharge waters from sources lying outside this ore-bearing zone.

This recharge pattern may also be responsible for varying radiologic concentrations, particularly gross alpha levels. Since phosphate ore is known for its elevated radiologic levels, the presence of a substantial level of dissolved gross alpha (values approaching 115 picocuries/liter) in the Surficial Aquifer is not unexpected. A similar trend would also be expected in the radium-226 determinations but was not found. A possible explanation for this absence may be that suspended solids levels in the Surficial Aquifer have masked the presence of radium in these waters by partially absorbing its radiation.

The increase of hydrogen sulfide levels with depth, on the other hand, is merely indicative of a change from slightly aerobic to anaerobic conditions in these groundwaters. The levels in the Surficial Aquifer are fairly substantial from a drinking water standpoint and point to the presence of depressed dissolved oxygen levels in the surface waters serving as the main recharge source for this upper aquifer.

Levels of total dissolved solids observed in the Surficial Aquifer also seem to bear a general relationship to the overlying surface water bodies. Concentrations of total dissolved solids in the Surficial Aquifer are high (≃460 mg/l) in those areas which underlie relatively quiescent waters, such as marshes. These values, however, drop in those areas subject to water movement. Dissolved solids concentrations in the Surficial Aquifer drop to a low of 60 mg/l in the eastern portion of the site due to the dilutional effects of inflows from the Peace River.

Compliance With Standards/Criteria

In order to better gauge the overall quality of the above described groundwaters, a comparison of their observed quality levels with applicable State of Florida and Federal criteria and standards was conducted. Based on the assumption that the highest beneficial use for these waters would be their use as a potable water supply, the listing in Table 6-9 was developed.

Of the above standards, the hydrogen sulfide standard was most frequently violated. Violations occurred in all three of the aquifers.

The only other violations (total iron and radium-226) observed were limited to the Surficial Aquifer. While these violations do limit the acceptability of these waters, and in particular the Surficial Aquifer, for drinking water purposes, it should be noted that all of these higher levels are the result of natural phenomena, not man-made activities.

6.2 ENVIRONMENTAL CONSEQUENCES OF THE ALTERNATIVES

The proposed mining and processing of phosphate rock at the Farmland site and subsequent reclamation of disturbed land will result in adverse impacts on groundwater quantity and quality at the site. This section contains a description of the groundwater quantity and quality impacts associated with the alternative methods of accomplishing the identified project goals. The discussion is arranged by project component so that the alternative methods for any given component can be examined to an equal degree, thus providing a basis for the comparison of alternatives. The first alternative discussed under each component is Farmland's proposed action (Section 2.0). Only those project components having impacts relating to water quantity and quality are considered in this section. The last discussion within the section considers the impacts of the no action alternative as it applies to the project as a whole.

6.2.1 MINING

Dragline Mining (Farmland's Proposed Action)

Quantity. The impacts of dragline mining on groundwater quantity will be associated primarily with the Surficial Aquifer as a result of withdrawals for pump seal requirements and the dewatering mine pits. Water will be withdrawn from the Surficial Aquifer at a maximum rate of 0.36 mgd for pump seal lubrication. This water will come from five proposed wells, each having a maximum pumping capacity of 50 gpm. Although the exact location of the wells has not yet been determined, they will be positioned such that the resultant drawdown from pumping will not extend offsite. Each well will be properly abandoned when the dragline is moved to a part of the site more easily served by a new well.

Water seeping into mine pits will be collected and added to the recirculating production water supply. Seepage into pits will vary from one area to the next depending on the length of the mine cut, but will average about 500 gpm (Farmland 1979b). This will cause local lowering of the water level in the Surficial Aquifer. Under SWFWMD regulations the water table should not be lowered by more than 3 feet at the property boundaries. In order to prevent this from occurring, Farmland proposes to construct rim ditches between the mine pits and adjacent property boundaries in areas where water table decreases could be significant. These will be kept filled with water. Seepage into the ground will help maintain the water table level beneath the neighboring property.

Quality. Dragline mining should not result in any significant changes in groundwater quality.

Dredge Mining

Quantity. Use of dredge mining would maintain water levels in the surrounding Surficial Aquifer; however, increased pumping of the Floridan Aquifer would be required to maintain water levels in the dredged pits during dry seasons. This added pumping of the Floridan Aquifer would cause increased declines in the piezometric head in the Floridan Aquifer.

Quality. The water contained within the active mining area would likely be turbid and contain higher concentrations of some parameters than water in the adjacent undisturbed Surficial Aquifer. At times when the level of the Surficial Aquifer is below the water level in the active mining area, some of this water could move laterally and degrade its quality. However, the resultant impacts on groundwater quality in the area should be insignificant.

Bucketwheel Mining

Quantity. The impacts of bucketwheel mining on groundwater quantity would be similar to those described for dragline mining.

Quality. Bucketwheel mining should not result in any significant changes in groundwater quality.

6.2.2 MATRIX PROCESSING

Conventional Matrix Processing (Farmland's Proposed Action)

Quantity. Conventional matrix processing requires that groundwater be used in combination with flotation reagents to separate the various fractions of the matrix. Under normal operating conditions, groundwater will be pumped at a rate of 8.8 MGD from the Floridan Aquifer. Figure 6-29 presents the projected drawdown which this withdrawal would produce. The contours shown in this figure were generated using the Trescott finite difference model (Trescott 1973) and pump test data acquired for Farmland's Consumptive Use Permit Application, administered by the Southwest Florida Water Management District (SWFWMD). As presented, the drawdown contours represented are the result of withdrawals from a single well located at the beneficiation plant. Farmland plans to evaluate the effects of the Floridan pumping in more detail with SWFWMD so that all drawdown regulations enforced by SWFWMD can be met (i.e., no more than 5 feet at the property boundary, unless a variance

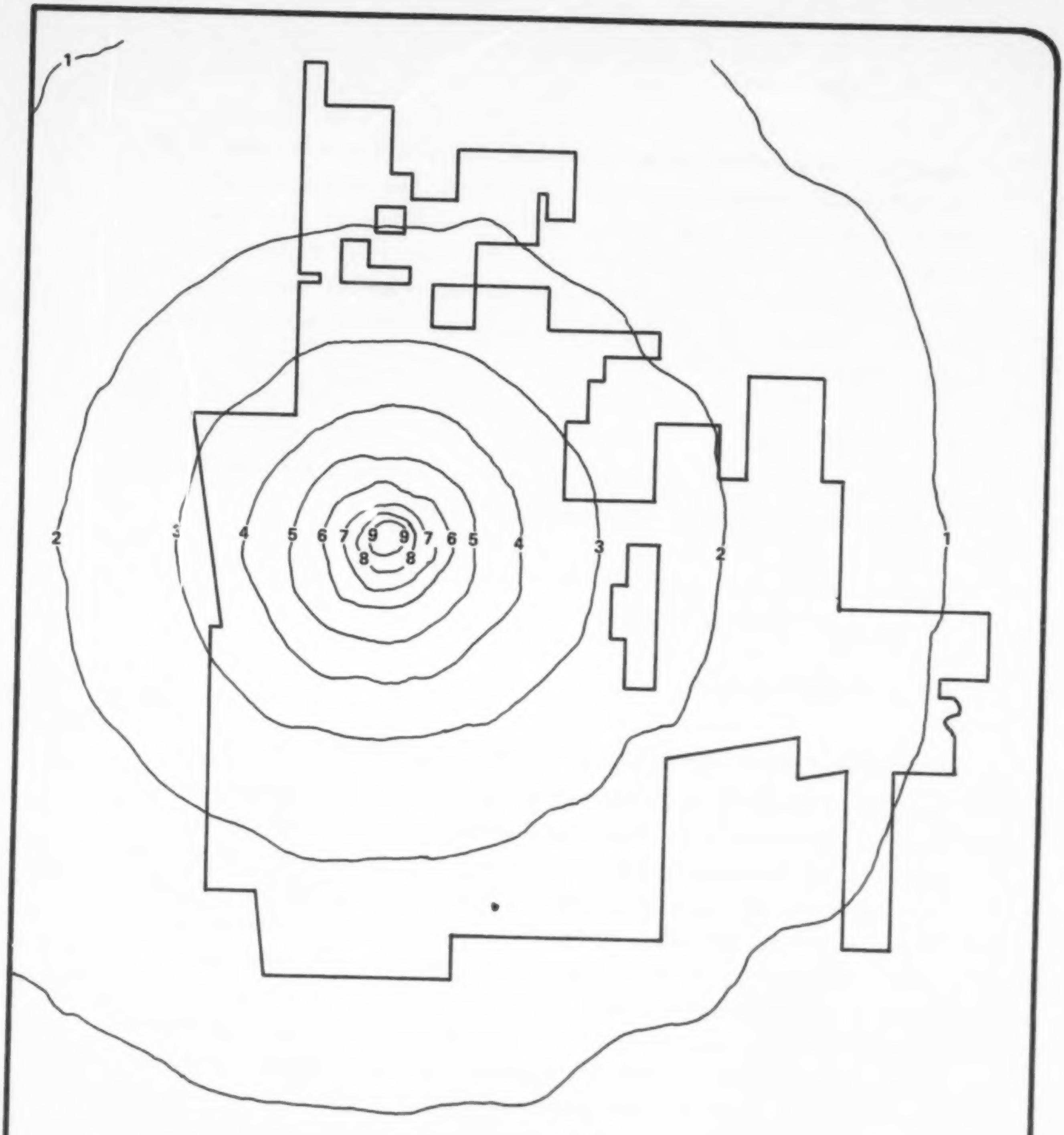

1
2
3
4
5
6
7
9
8
9
8
7
6
5
4
3
2
1
N
0
2,000
4,000
SCALE IN FEET

FIGURE 6-29. IMPACT OF PROPOSED PRODUCTION WELL M-1 ON FLORIDAN AQUIFER.

SOURCE: ADAPTED FROM DATA PROVIDE BY FARMLAND INDUSTRIES, INC.

is granted). The Trescott model predicts a maximum steady state drawdown of about 31 feet. This may require that pumping be halted temporarily during dry periods in order to prevent the potentiometric surface from dropping below sea level--violating SWFWMD regulations.

All the impacts to potentiometric surface in the Floridan Aquifer are expected to be temporary. The potentiometric level is expected to recover once pumping is ended, in much the same way that the aquifer recovers from the irrigation pumping each year.

Quality. The elevation of the saltwater-freshwater interface below the site was determined using the Ghyben-Herzberg principle. Its location was estimated to be 2100 feet below mean sea level in March 1978. The great distances to the interface and the probable presence of a relatively impermeable evaporite stratum at the base of the Avon Park Limestone should substantially prevent the upward migration of mineralized water into the Floridan Aquifer (PELA 1979b).

Dry Matrix Processing

Quantity. Dry matrix processing would involve the use of air and/or electrostatic separation of the matrix fractions. Thus, the drop in the potentiometric head of the Floridan Aquifer predicted for the pumping discussed above should not occur.

Quality. Dry matrix processing should not result in any significant changes in groundwater quality.

6.2.3 PROCESS WATER SOURCES

Groundwater Withdrawal (Farmland's Proposed Action)

Quantity. The impacts of groundwater withdrawal on qroundwater quantity are discussed under "Conventional Matrix Processing", above.

Quality. The impacts of groundwater withdrawal on groundwater quality are discussed under "Conventional Matrix Processing", above.

Surface Water Impoundment

Quantity. Impounded surface waters collected from above average flows of onsite streams would provide a process water source which would be capable of satisfying all project requirements. Therefore, surface water impoundment should not result in any significant changes in deep (Floridan) groundwater quantity. Surface water impoundment would also help maintain the water table height in the Surficial Aquifer, at least in the vicinity of the impoundment.

Quality. Impounded surface waters collected from above average flows of onsite streams would provide a process water source which would be capable of satisfying all project requirements. Therefore, surface water impoundment should not result in any significant changes in deep (Floridan) groundwater quality.

6.2.4 WASTE SAND AND CLAY DISPOSAL

Sand-Clay Mixing (Farmland's Proposed Action)

Quantity. Farmland proposes to dispose of most of the waste sand and clay from the beneficiation plant in the form of a sand-clay mix. This material will be placed into mined areas once space becomes available. Separate sand and clay disposal areas will also be required during the life of the mine. Disposal of waste clay in a separate impoundment (Area I, 495 acres) during the initial years of operation is required because sufficient mined area will not be available for sand-clay mix disposal. During following years, separate disposal area (Area II, 483 acres) is required in order to control the ratio of sand:clay in the mix used to fill mined areas. In order to make the initial settling pond (Area I) functional, it will be filled with water from the Floridan

Aquifer prior to operation. This will require the withdrawal of about 8.8 mgd over a period of about 1 year. This withdrawal of water from the Floridan Aquifer will produce a drawdown similar to that which will occur during normal operations (Figure 6-29). Area II will be filled with water from the recirculating water system and thus should not result in any additional impacts on groundwater quantity.

Much of the water withdrawn during normal operations (about 8.8 mgd) will be entrained within the waste disposal areas. During the initial years of operation (when waste sand and clay are disposed of separately) this will amount to about 4.5 mgd. It is anticipated that this loss of water through entrainment will be reduced when sand-clay mixing is used, but the actual degree of success for water recovery is not known at this time.

Farmland's proposed waste disposal plan will also affect the quantity of water in the Surficial Aquifer, for some of the water used to transport waste sand and clay and from the ditches and ponds which comprise the water recirculation system will seep into the Surficial Aquifer. Under average annual conditions, this should amount to about 4.5 mgd (Farmland 1979a; 1979b).

Quality. As indicated above, some of the water used to transport these wastes would seep into the Surficial Aquifer. This water, if contaminated during use, could move laterally and degrade the quality of the Surficial Aquifer in adjacent areas. Ardaman (1980) reports that the coefficient of horizontal permeability for the Surficial Aquifer is one the order of 5.0×10^{-3} cm/sec, or about 15 ft/day.

One way to characterize the water quality effects of mixing mine and beneficiation plant water with Surficial groundwaters is to compare existing characterizations of such waters from other mining operations with the quality of Surficial Aquifer waters. This comparison is made in Table 6-10. The slime supernatant water is the average of analyses from 15 beneficiation plants in Florida. According to this comparison, Surficial Aquifer water quality would be degraded in a localized area around the sand-clay mixtures. Concentrations of most constituents would increase in the area near the reclamation sites. While the concentrations of a number of constituents would increase, available data do not indicate water quality standards would be exceeded. Concentrations of fluoride in the slime supernatant exceed the 1.5 mg/l groundwater standard for Florida by about 33 percent. It is expected that available mixing would lead to fluoride concentrations below the standard within a short distance from the reclamation activities. Ra-226 concentrations are not expected to rise significantly above background levels.

Conventional Sand and Clay Disposal

Quantity. In conventional sand and clay disposal, all of the waste sand and clay generated by the beneficiation plant would be disposed of in separate areas--that used for clay disposal totaling about 2700 acres. Such areas would, as described for Farmland's proposed action, be a source of seepage to the Surficial Aquifer. However, the settled clays may form more of a natural "liner" than sand-clay mix will, significantly reducing such movement.

The increased entrainment of water by the separately impounded clays over the life of the mine would increase the amount of water "lost" relative to sand-clay mixing. Data presented by Farmland (1979b) indicate that the loss incurred through such clay areas could be on the order of 4.5 mgd.

Quality. As stated above, the disposal of waste sand and clay in separate areas might provide for better containment of the water used for their transport. This would reduce seepage and thus the impacts on the quality of the Surficial Aquifer from that described above for Farmland's proposed plan.

6.2.5 WATER MANAGEMENT PLAN

Discharge to Surface Waters (Farmland's Proposed Action)

Quantity. A discharge to surface waters should not result in any significant changes in groundwater quantity.

Quality. A discharge to surface waters should not result in any significant changes in groundwater quality.

Connector Wells

Quantity. Connector wells could be used to discharge uncontaminated water from the recirculating water system to the deep aquifers. This would to some degree offset the withdrawal of groundwater from the Floridan Aquifer for processing.

Quality. Disposal of collected surface water in deeper aquifers may improve water quality (in the aquifer) in terms of dissolved solids, but would probably degrade groundwater quality constituents such as fluoride, phosphate, and nitrate.

6.2.6 THE NO ACTION ALTERNATIVE

Quantity. Under the no action alternative no appreciable changes in the existing groundwater environment are anticipated. The present seasonal changes in water levels in the Surficial, Secondary Artesian, and Floridan Aquifers will not be affected. The seasonal pumping of the Floridan Aquifer by the nine onsite high-capacity irrigation wells will continue as will their resultant drawdowns. This alternative will also cause no changes in the hydrologic characteristics of the Surficial Aquifer or change in rate of baseflow to the local surface water courses.

Quality. Groundwater quality under the no action alternative will depend on the future uses for land in the area. If land use patterns in the immediate area remain fairly constant over the next few decades, groundwater quality should remain much as it is today.

6.3 REFERENCES

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Table 6-1. AGE, THICKNESS, AND LITHOLOGY OF STRATIGRAPHIC UNITS IN THE FRESH-WATER BEARING SECTION OF THE CENTRAL FLORIDA PHOSPHATE DISTRICT IN HARDEE AND DE SOTO COUNTIES, FLORIDA.

Geologic Age		Stratigraphic Unit		Thickness (feet)	Lithology	Remarks and Identifying Criteria
Period	Epoch					
Quaternary and Tertiary	Holocene, Pleistocene, Pliocene, and Miocene	Surficial Deposits	Upper sand unit	0-70'	Sand, clayey, very fine to medium-grained, predominantly fine-grained; white to brown; trace of phosphate in lower part, minor thin beds of limestone and bluish gray clayey sand and clay.	
			Shell and sand unit	0-55	Sand and clayey sand, very fine-grained, gray to green; minor, to abundant shells, including large oyster and barnacle shells.	
			Phosphorite Unit	0-40	Clayey sand and sandy clay, fine-grained, calcareous to noncalcareous; abundant phosphorite nodules up to pebble size, white to gray in upper part, amber or black in lower part; includes beds of clean phosphatic sand and sand and gravel.	
Tertiary	Miocene	Hawthorn Formation	Hawthorn Formation and Limestone unit of Tampa Limestone, undivided	160-370	In upper part, predominantly marl, dolomite, and limestone; soft, chalky, fine-grained to sandy or pebbly; abundant brown or black phosphorite grains or pebbles; minor thin-bedded sand and clay. In lower part, predominantly limestone, massive or thick-bedded, hard, dense, cherty, fossiliferous, phosphatic, white to gray and brown; minor thin-bedded sand and clay. Where underlying sand and clay unit is absent, equivalent beds are limestone, predominantly sandy, fossiliferous, gray, cherty; in places marly, soft, pebbly.	Generally the uppermost limestone in the section, less clastic than underlying sand and clay unit of Tampa Limestone, phosphatic throughout. Shows highest radioactivity of the section on gamma-ray logs.
		Tampa Limestone	Sand and clay unit of Tampa Limestone	0-230	Sand, fine-coarse grained, clean to silty, limey, grayish green; and clay, silty, sandy, marly, gray to pale green, and hard, waxy, dark green to black, marly; minor limestone.	Less phosphatic than overlying beds, reflected in lower radioactivity on gamma logs. Sand and clay unit grades westward to sandy limestone (Limestone unit of Tampa Limestone).
	Oligocene		Suwannee Limestone	100-250	Limestone, nodular, granular, chalky, some fragmental, some oolitic, usually very fossiliferous, cream to white, occasionally some clear quartz strains.	Clean, nodular, non-phosphatic limestone contrasts to overlying phosphatic clastics. Very low radioactivity on gamma-ray log.
	Eocene		Ocala Group	260-400	Limestone, chalky, nodular, granular, fragmental, some oolitic, generally very fossiliferous, cream, white, some buff; occasional dolomite in lower part, sucrisic to dense and cherty, yellowish brown to dark-brown and gray.	*Lepidocyclina* sp. and/or *Camerina* fossils abundant. *Lepidocyclina* usually appears 20-40 feet above *Camerina*. Zone at low radioactivity occasionally marks the top on gamma-ray log.
			Avon Park Limestone	200-470	Limestone, chalky, nodular, oolitic, fragmental, intergranular anhydrite and gypsum, very fossiliferous, cream, white and full; commonly thin dolomite in middle part, dense to finely crystalline or sucrosic, yellow to grayish brown.	Distinctive fossil *Dictyoconus cookei*.
			Dolomite Unit	Maximum at least 150	Dolomite; massive, dense to finely crystalline or sucrosic, some crystalline, pale-yellow and brown to dark-brown and gray, mottled.	Lithology contrasts to overlying limestones; dolomite has high resistivity and self potential on electric log, and commonly high gamma radiation on gamma-ray log.

Source: P.E. Lamoreaux, Supporting Report for Consumptive Use Permit, April 1979.

Table 6-2. RESULTS OF THE SURFICIAL AQUIFER PUMPING TESTS 1 AND 2 ANALYZED BY THE BOULTON DELAYED YIELD EQUATION (BOULTON 1954, 1963, 1964).

Surficial Aquifer Pumping Test 1

Well Pumped	Well Observed	Part of Hydrograph Analyzed	Transmissivity (gallons per day per foot)	Specific Yield (Percent)
PT-1	PT01-1	Drawdown	10,000	14
PT-1	PT01-2	Drawdown	10,700	11
PT-1	PT01-3	Drawdown	9,800	9
PT-1	PT01-4	Drawdown	8,100	6
AVERAGE			9,700	10

Surficial Aquifer Pumping Test 2

Well Pumped	Well Observed	Part of Hydrograph Analyzed	Transmissivity (gallons per day per foot)	Specific Yield (Percent)
PT-2	PT02-1	Drawdown	11,500	22
PT-2	PT02-2	Drawdown	14,500	20
PT-2	PT02-3	Drawdown	11,800	19
PT-2	PT02-4	Drawdown	13,500	13
AVERAGE			12,800	19

Source: Farmland Industries, Inc. DRI June, 1979.

Table 6-3. RESULTS OF THE SECONDARY ARTESIAN AQUIFER (HAWTHORN FORMATION AND TAMPA LIMESTONE) PUMPING TEST[1]

Well Pumped	Well Observed	Part of Curve Analyzed	Transmissivity gpd/ft	Coefficient of Storage	Leakance gpd/ft^3
FIS-1	FIS-2	Drawdown	43,300	2.22×10^{-4}	0
FIS-1	FIS-3	Drawdown	43,300	2.82×10^{-4}	0
AVERAGE			43,300	2.52×10^{-4}	0

RESULTS OF THE FLORIDAN AQUIFER PUMPING TEST[1]

Well Pumped	Well Observed	Part of Curve Analyzed	Transmissivity gpd/ft	Coefficient of Storage	Leakance gpd/ft^3
FIF-1	FIF-2	Drawdown	550,000	5.7×10^{-3}	5.5×10^{-3}
FIF-1	FIF-3	Drawdown	550,000	1.3×10^{-3}	0.9×10^{-3}
FIF-1	SWFWMD-1	Drawdown	500,000	4.8×10^{-4}	0.6×10^{-3}
FIF-1	FIF-1	Recovery	513,000	---	---
AVERAGE			528,000	2.5×10^{-3}	2.3×10^{-3}

[1] Analyzed by method of Hantush and Jacob (1955 as modified by Cooper, 1963).

Source: Farmland Industries, Inc. DRI, June 1979.

Table 6-4. WATER WELL INVENTORY (LESS THAN 6" DIAMETER) IN THE VICINITY OF THE FARMLAND INDUSTRIES, INC. SITE.

Map I.D. No.	Well No. (Lat. - Long.)	Owner	Depth (feet)	Diam. (in.)	Use[1]
0508[2]	272305N815808	V. C. Hollingsworth	23.2	3	I
1048	272310N815548	Bishop	22	2	D
1630	272316N815530			2	I
1755	272317N815555	Bishop	150	2	I
1753	272317N815753	L. R. Coker	30	2	I
0103.1	272401N815503.1	J. Norris		2	I
0103.2	272401N815503.2	J. Norris		2	D
0926	272409N815526			2	D
1101	272411N815801	Tomlinson		2	I
1216	272412N815516			3	D
1219	272412N815519			2	I
1223	272412N815523			3	U
1333	272413N815433			2	D
1509	272415N815509	U. L. Coker	20	2	D
1729	272417N815529	L. R. Coker	12-20	3	D
2018	272420N815518			2	D
3001	272430N815801	D. Tomlinson	52.5	2	D
3815	272438N815515	Farmland	23	2	O
3916	272439N815516	Farmland		2	O
4002	272440N815602	Farmland		2	O
4226	272442N815726	Paul English	18	4	D
4301	272443N815501	Margaret Weber	35.5	4	I
4303	272443N815503	Margaret Weber	56	2	I
4322	272443N815722	Paul English	18	1 1/4	D
4416	272444N815716	Paul English	16	4	I
4423	272444N815723	Paul English	18	4	I
4400	272444N815800	Owen & Williams		4	U
5012	272450N815712	Paul English	20	2	D
5126	272451N815726	Paul English	43	2	I,S
5302	272453N815702	Margaret Weber	29	2	I
5718	272457N815718	Farmland	97	2	O
5811	272458N815511	Margaret Weber	24.5	2 1/2	I
5817	272458N815817	C. Harly	25	2	I
0040	272500N815540	Farmland	20	2	I, S
0103.1	272501N815503.1	Margaret Weber	36	4	I
0103.2	272501N815503.2	Margaret Weber	72	2	I
0602	272506N815502	Farmland	50	2	O
0747	272507N815547	Farmland	115	2	O
0840	272508N815840	Carlton	16.2	2	D
0842	272508N815842	Carlton	20	2	S
0847	272508N815847	Carlton	23	2	S
1636	272516N815836	Carlton	16.3	3	S
2616	272526N815516	Farmland	30	2	I, S
2622	272526N815722	Farmland		2	O
2633	272526N815733	Rojan, Inc.	12.5	2	I

Table 6-4. WATER WELL INVENTORY (LESS THAN 6" DIAMETER) IN THE VICINITY OF THE FARMLAND INDUSTRIES, INC. SITE, continued.

Map I.D. No.	Well No. (Lat. - Long.)	Owner	Depth (feet)	Diam. (in.)	Use
2940	272529N815540	Farmland	69	2	O
3128	272531N815428	Farmland	35	2	O
4033	272540N815533	Farmland	20	2 1/2	U
4237	272542N815637	Farmland		2	O
4531	272545N815231	Farmland	45	2	O
4938	272549N815738	Paul Smith		2	D
4952	272549N815752	Paul Smith		1 1/4	D
5529	272555N815029	B. H. Griffin	82	2	U
5746	272557N815546	Farmland	24	2	O
0002	272600N815502	Farmland	46	2	O
0249	272602N815749	Harry Smith		2	I
0354	272603N815354	Farmland	55	2	O
0344	272603N815444	Farmland	50	2	O
0823	272608N815123	Farmland	35	2	O
1700	272617N815500	Farmland	35	2	I, S
2531	272625N815331	Farmland	45	2	O
2607	272626N815207	Overlook Groves		2	I
2658	272626N815458	MCC	28	2	O
2922	272629N815222	Overlook Groves		2	I
2923	272629N815823	Farmland	79	2	O
3015	272630N815215	Overlook Groves		4	I
3126	272631N815226	Overlook Groves		2	I
3203	272632N815603	Farmland	16	2	O
3314	272633N815214	Overlook Groves		2	I
3400	272634N815200	Overlook Groves		2	I
3406	272634N815506	Farmland		2	O
3449	272634N815549	Farmland	12.6	1 1/4	S
3441	272634N815741	Farmland	80	2	O
3607	272636N815307	Farmland	53	2	O
3751	272637N815251	Farmland	55	2	O
4123.1	272641N815923.1	McSwain	11	3	I
4123.2	272641N815923.2	McSwain	13	3	I
4234	272642N815134	Farmland	53	2	O
4414	272644N815414	Farmland	45	2	O
4530	272645N815630	Farmland	23	2	O
4944	272649N815244	Farmland	50	2	O
5053	272650N815853	McSwain	15	3	D
5011.1	272650N815911.1		180	4	I
5011.2	272650N815911.2			2	D
5149	272651N815649	Farmland		1	D
5211	272652N815211	Farmland		1	D
5723	272657N815923	McSwain	6.5	3	D
5947	272659N815647	Farmland		2	I,S
0051	272700N815651	Farmland	33	2	O
0313	272703N815213	Farmland	75	2	O
0314.2	272703N815214.2	Farmland	75	2	O
0314.3	272703N815214.3	Farmland	75	2	O
0331	272703N815231	B. J. & D. A. Keene			D

Table 6-4. WATER WELL INVENTORY (LESS THAN 6" DIAMETER) IN THE VICINITY OF THE FARMLAND INDUSTRIES, INC. SITE, continued.

Map I.D. No.	Well No. (Lat. - Long.)	Owner	Depth (feet)	Diam. (in.)	Use
0414	272704N815214	Farmland	75	2	O
0743	272707N815643	Farmland		2	D
1020	272710N815820	Farmland	45	2	O
1233	272712N815233	J. E. Keene		4	U
1234	272712N815234	J. E. Keene	30	2	S
1230	272712N815730	Farmland	70	2	O
1323	272713N815023	B. H. Griffin		3	U
1321	272713N815521	Farmland	91	2	O
1359	272713N815559	Farmland	74	2	O
1338	272713N815638	Farmland		1 1/4	U
1502	272715N815302	Farmland	55	2	O
1711	272717N815911		15	3	D
1832	272718N815232	J. E. Keene	30	1 1/2	D
2131	272721N815231	J. E. Keene	30	1 1/2	D
2200	272722N815500	MCC	35	2	O
2444	272724N815344	Farmland	45	2	O
2535	272725N815235	J. E. Keene	30	2	D
2633	272726N815233	J. E. Keene	30	2	D
2931	272729N815231	Alvin Miller	30	2	D
3031	272730N815631	Farmland	61	2	O
3332	272733N815432	Farmland	30	2	S
3421	272734N815321	Farmland		2	U
3555	272735N815455	Farmland	55	2	O
4032	272740N815232	Farmland	45	2	O
4101	272741N815401	Farmland	25	4	U
4211	272742N815611	MCC	45	2	O
4310	272743N814910			2	D
4436	272744N815736	Farmland	77	2	O
4523	272745N815823	Farmland	52	2	O
4800	272748N815400	Farmland	25	2	U
4913	272749N815913	McSwain (IMC)		1 1/4	D
5736	272757N815736	Farmland		1 1/4	S
5938	272759N815238	B. W. Perrine		1 1/4	D
5918	272759N815718	Farmland	85	2	O
0137	272801N815237	B. W. Perrine		3	I
0619	272806N815819	Farmland	56	2	O
0747	272807N815547	MCC	47	2	O
0830	272808N815630	Farmland	78	2	O
0828	272808N815928			1 1/4	D
1036	272810N815236	L. B. Farabee		2	D
1143	272811N815243	D. A. Farabee	18	3	D
1239	272812N815539	Sue Smith			S
1407	272814N815207	Cole	100	4	D
1434	272814N815234	Arline Wolfe		2	D
1440	272814N815240	D. A. Farabee	15	3	I
1548	272815N815448	Farmland	45	2	O
1532	272815N815532			4	I,S

Table 6-4. WATER WELL INVENTORY (LESS THAN 6" DIAMETER) IN THE VICINITY OF THE FARMLAND INDUSTRIES, INC. SITE, continued.

Map I.D. No.	Well No. (Lat. - Long.)	Owner	Depth (feet)	Diam. (in.)	Use
1600	272816N815200	Farmland	55	2	O
1757	272817N815457	MCC	46	2	O
1704	272817N815904	Wessel		1	D
1711	272817N815911	Wessel		2	S
1817	272818N815317	Farmland		1 1/2	U
2034	272820N815234	W. A. Cole	12	4	D
2019.2	272820N815719.2	MCC	40	2	O
2018	272820N815818	MCC	16	2	O
2248	272822N815248	W. & I. J. Jernigan		2	D
2317	272823N815317	Farmland	20	4	U
2743	272827N815243	Ivey Keene	20	1 1/4	D
2813	272828N815213	Herbie Kay		2	D
2841	272828N815241	Merle Whidden		1	D
3135.1	272831N815235.1	Tommy Irby	12	2	D
3135.2	272831N815235.2	Tommy Irby	21	2-3	U
3141.1	272831N815941.1	Bennett	200	2	D
3141.2	272831N815941.2	Doying	100		D
3141.3	272831N815941.3	Doying	13.7	3 1/2	U
3427	272834N815227	Ann Brown		1 1/4	D
3558.2	272835N815358.2	Farmland	45	2	O
3558.3	272835N815358.3	Farmland	45	2	O
3558.4	272835N815358.4	Farmland	45	2	O
3658	272836N815358	Farmland	45	2	O
3719	272837N815119	Hupps	300	4	D
4101	272841N815401	Farmland	55	2	O
4117	272841N815517	MCC	30	2	O
4210	272842N815310	Farmland	55	2	O
4226	272842N815526	Sue Smith		4	I
4733	272847N815433	MCC	40	2	O
4818	272848N815218	Mrs. L. Whidden		2	D
4801	272848N815301	H. Hanchey		3	U
5027.1	272850N815227.1	Paul Crowe		3	I
5027.2	272850N815227.2	Paul Crowe		2	I
5251	272852N815551	MCC	40	2	O
5301	272853N815301	Hitchcock Prod., Inc.		4	U
5423	272854N815223			1 1/2	D
5425	272854N815225	Paul Crowe		2	I
5428	272854N815228	Paul Crowe		2	D
5520	272855N815220	Rainey Groc.	200	2	U
5500	272855N815400			1	D
5613	272856N815313	Lloyd Holt	26	1 1/4	D
5657	272856N815357	Ridzelski	35	1 1/2	D
5603	272856N815403	S. A. Browning		2	S
5604	272856N815404	S. A. Browning		4	D
5612	272856N815412	Robert Woods		2	U

Table 6-4. WATER WELL INVENTORY (LESS THAN 6" DIAMETER) IN THE VICINITY OF THE FARMLAND INDUSTRIES, INC. SITE, continued.

Map I.D. No.	Well No. (Lat. - Long.)	Owner	Depth (feet)	Diam. (in.)	Use
5627	272856N815427	Robert Bird		2	D
5756	272857N815356	Ridzelski	35	2	U
5850	272858N815350	B. K. Suggs	35	1 1/4	U
5852	272858N815352	B. K. Suggs	35	2	U
5808	272858N815408	Robert Woods		2	D
5804	272858N815804	MCC	15	2	O
0009	272900N815409	Audrey Woods		2	D
0143	272901N815843	T. Platt	24	2	D
0356	272903N815856	B. H. Griffin		4	D
0433	272904N815833			2	D
0436	272904N815836			2	D
0441	272904N815841			2	D
0659	272906N815059				I
0614	272906N815514	MCC	25	2	O
0712	272907N815412	Robert Woods		2	D
0727	272907N815627	MCC	25	2	O
1125	272911N815725	MCC	16	2	O
1203	272912N815803	MCC	12	2	O
1228	272912N815928	Carlton			D
1403	272914N815403	John Beattie	58	2	D
1558	272915N815458	MCC	45	2	O
1554	272915N815854	MCC	45	2	O
1652	272916N815352	Farmland		2	S
2818	272928N815418	Farmland		2	D
3123	272931N815323	Farmland	45	2	O
3530	272935N815330	MCC	46	2	O
4203	272942N815403	Farmland	45	2	O
4811	272948N815811	MCC	23	2	O
5124	272951N815624	D. Carlton		3	S
5252	272952N815552	MCC	40	2	O
5332	272953N815232	L. C. Clark	38	4	I
5340	272953N815240	L. C. Clark	38	4	I
5431	272954N815431	MCC	45	2	O
5432	272954N815632	MCC	25	2	O
4008	273040N815508			2	D
4511	273045N815611	MCC	36	2	O

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[1] D = Domestic; O = Observation/Test; I = Irrigation; U = Unused; S = Stock; IMC = International Minerals Corp.; MCC = Mississippi Chemical Corp.

[2] Map on file at Farmland Industries, Inc.

Source: P.E. LaMoreaux & Associates, Inc. Revised Well Inventory, November 1979 for Farmland Industries, Inc.

Table 6-5. WATER WELL INVENTORY (6" DIAMETER OR LARGER) IN THE VICINITY OF THE FARMLAND INDUSTRIES, INC. SITE.

Map I.D. No.	Well No. (Lat. - Long.)	Owner	Depth (feet)	Diam. (in.)	Yield (GPM) Max.	Use [1]
4408 [2]	272244N815808	Strickland		12	144	I
1701	272317N815801	Hollingsworth	43.1	12		I
2357	272323N815657	U. of F.		6		S
2416	272324N815716	U. of F.		6		I
2610	272326N815810		1180	10		I
3743	272337N815743	Tomlinson		10		I
0109	272401N815509	J. Norris	521	8		I
0434	272404N815534	Robert Norris	1070	8		I
1302	272413N815402	Overlook Groves	1032	20		I
1545	272415N815345	Overlook Groves	750	16	1000	I
1546	272415N815546	J. Norris	1100	10		I
1643	272416N815743	D. Tomlinson		10		I
2523	272425N815523	Roda	781	10	600	I
3014	272430N815814	Tomlinson		10		I
3120	272431N815520	U. of F.	781	10	600	I
3206	272432N820006	Jimmy Gray		12		I
3614	272436N815414	Overlook Groves	450	8	750	I
3740	272437N815340	Overlook Groves	1300	16		I
4058	272440N815658	Farmland	15	6		O
4000	272440N815700	Farmland	61	6		O
4002	272440N815702	Farmland	15	6		O
4228	272442N815728	E. & J. Houston		≥6		I
5518	272455N815318	Overlook Groves	1300	10	500	I
0049	272500N815749		880	10		I
0356	272503N815456	Berry Groves, Inc.		12	458	I
0404	272504N815404	Overlook Groves	1300	12	1500	I
0417	272504N815417	Overlook Groves	1200	12	625	I
2607	272526N815507	Farmland	1100	12	1750	I
2900.1	272529N815500.1	Farmland	20	6		O
2900.2	272529N815500.2	Farmland	46	6		O
3424	272534N815524	U. of F.		6		I
3611	272536N815311	B. & P. Carlton		8		I
3657	272536N815657	Farmland	1150	12	1750	I
3924	272539N815424	Farmland		6		I
4054	272540N815254	Berry Groves, Inc.		12		I
4222	272542N815222	Overlook Groves	1350	16	1000	I
4256	272542N815256	B. & P. Carlton	950	12		I
4413	272544N815313	Farmland		6		U
4825	272548N815225	Louis Abrons		12		I
5117	272551N815717	M. Carlton	1000	6		S
5456	272554N815356	Farmland	1080	12	833	I
1050	272610N815850	IMC		8		I
1718	272617N815718	D. Carlton	1000	6		I, S
1909.1	272619N815709.1	Farmland	20	6		O
1909.2	272619N815709.2	Farmland	31	6		O
2250	272622N815250	Farmland		20	450	I

Table 6-5. WATER WELL INVENTORY (6" DIAMETER OR LARGER) IN THE VICINITY OF THE FARMLAND INDUSTRIES, INC. SITE, continued.

Map I.D. No.	Well No. (Lat. - Long.)	Owner	Depth (feet)	Diam. (in.)	Yield (GPM) Max.	Use
2657	272626N815457	Farmland	40	8		I
5412	272654N815212	Farmland		20	450	I
0314.1	272703N815214.1	Farmland	77.5	8		O
0701	272707N815301	Farmland		20	1200	I
1309	272713N815509	Farmland		6		O
1459.1	272714N815459.1	SWFWMD-1	1152	8		O
1459.2	272714N815459.2	SWFWMD-2	350	6		O
1459.3	272714N815459.3	SWFWMD-3	15	6		O
2211	272722N815911		15	6		I
2306	272723N815206	Farmland	1050	12	1000	I
2737	272727N815137	Farmland	40	8		O
3737	272737N815237	B. E. & S. A. Huddleston		6		I
3706	272737N815406	Farmland	1400	12		O
3900	272739N815400	Farmland	1400	12		O
3901	272739N815401	Farmland	387	8		O
4001.1	272740N815401.1	Farmland	1400	18		O
4001.2	272740N815401.2	Farmland	55	8		O
4310	272743N814910	Glenn Slaughter	710			I
4951	272749N815851			14		I
5051	272750N815851			10		I
0303	272803N815403	Farmland		6		S
0447	272804N815247	R. & S. Pridgen	50-60	6		I
0452	272804N815552	D. Carlton, MCC		10		I
0845	272808N815545	Sue Smith	800	12	2000	I
0924	272809N815324	Farmland		10	450	I
0936	272809N815836	Wessel		12		I
1145	272811N815545	Donald Smith		12	2000	I
1232	272812N815132	H. H. Harland		6		I
1538	272815N815338	Farmland		10	450	I
1514	272815N815714	Farmland	78	6		O
1736	272817N815136	H. H. Harland		10		I
2019.1	272820N815719.1	MCC	20	6		O
2136	272821N815236	W. & A. Cole	385	6		I
2513	272825N815213	Herbie Kay	750	10		I
2622	272826N815922	B. H. Griffin		10		I
2825	272828N815225	Herbie Kay	750	12X8		I
3427	272834N815127	Ann Brown		8		I
3558.1	272835N815358.1	Farmland	45	8		O
4619	272846N815119	Republic Nursery	1166	8		I
4708	272847N815208	R. L. Holt	1000	10		I
4825	272848N815225	Himrod	750	6		I
4915	272849N815515	MCC	20	6		O
5124	272851N815124	Republic Nursery	350	6		I
5125	272851N815125	Republic Nursery	350	6		I
5141	272851N815341	F. Mancini		6		I
5216	272852N815916	B. H. Griffin	800	6		I
5713	272857N815213	Robert Campbell		12		I

Table 6-5. WATER WELL INVENTORY (6" DIAMETER OR LARGER) IN THE VICINITY OF THE FARMLAND INDUSTRIES, INC. SITE, continued.

Map I.D. No.	Well No. (Lat. - Long.)	Owner	Depth (feet)	Diam. (in.)	Yield (GPM) Max.	Use
0212	272902N815112			8		I
0312	272903N815112			8		I
0828	272908N815928	MCC	15	6		O
0911	272909N815111	Sunny South Packing		8		I
1921	272919N815021	D. R. Stewart		6		U
2126	272921N815226	Ewell Sweet		10		I
2407	272924N815107	Ren Groves		8		I
2407	272924N815207	Robert Bateman		10		I
2648	272926N815048	Maddox		12		I
2803	272928N815003	Gillard Groves		8		I
2817	272928N815217			10		I
3026	272930N815226	Richard & Carney		10		I
3600	272936N815400	MCC	20	6		O
3838	272938N815038	Henry M. Roe		8		I
3924	272939N815124	Ed Dean	990	10		I
4550	272945N815050			8		I
5052	272950N815752	D. Carlton		12	2000	I
5119	272951N815119	T.Williams/J.Davis		12		I
5132	272951N815132	J. Himrod	900	8		I
5725	272957N815225	L. C. Clark	1128	10		I
5816	272958N815716	D. Carlton		12	2000	I
0009	273000N815209	Ewell Sweet		12		I
0750	273007N815350	Martha C. Ward		10		S
2407	273024N815607	MCC	1205	12		C
2807.1	273028N815607.1	MCC	1201	16	2967	O
2807.2	273028N815607.2	MCC	12	8		O
2808.1	273028N815608.1	MCC	1140	12		O
2808.2	273028N815608.2	MCC	710	8		O
2905.1	273029N815605.1	MCC	1205	8		O
2905.2	273029N815605.2	MCC	364	8		O
3453	273034N815353	D. Ward	876	12	2000	I
4019	273040N815419	Doyle Carlton	617	8	253	I
4759	273047N815159	L. C. Sasser		10		I
5235	273052N815535	Doyle Carlton	850	12	1000	I
0913	273109N815413	Doyle Carlton	850	12	30	I
1003	273110N815303	MCC	20	6		O
1353	273113N815353	Tilly Groves		10		I
1938	273119N815538	MCC	10	6		O

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[1] D = Domestic; O = Observation/Test; I = Irrigation; U = Unused; S = Stock; IMC = International Minerals Corp.; MCC = Mississippi Chemical Corp.

[2] Map on file at Farmland Industries, Inc.

Source: P.E. LaMoreaux & Associates, Inc. Revised Well Inventory, November 1979 for Farmland Industries, Inc.

Table 6-6. WATER QUALITY PARAMETERS FOR ANALYSIS OF SAMPLES COLLECTED OCTOBER 16 - 17, 1979, AT SELECTED GROUNDWATER MONITORING STATIONS.[1]

INORGANICS

- Ammonia, Nitrogen[2]
- Arsenic (ug/l)
- Barium (ug/l)
- Beryllium (ug/l)
- Bicarbonate
- Cadmium (ug/l)
- Calcium
- Carbonate
- Chloride
- Chromium (VI) (ug/l)
- Copper (ug/l)
- Cyanide (ug/l)
- Fluoride
- Hydrogen Sulfide
- Iron (ug/l)
- Lead (ug/l)
- Magnesium
- Manganese (ug/l)
- Mercury (ug/l)
- Nickel (ug/l)
- Nitrate, Nitrogen
- Nitrite, Nitrogen
- Phosphorus, Total
- Ortho Phosphate
- Potassium
- Selenium (ug/l)
- Silica, Total
- Silver (ug/l)
- Sodium
- Solids, Dissolved
- Solids, Suspended
- Sulfate
- Zinc (ug/l)

ORGANICS

- Endrin (ug/l)
- MBAS
- G-C Scan for Total Organochlorine Pesticides
- Lindane (ug/l)
- Methoxychlor (ug/l)
- Oil and Grease
- TDC
- TOC
- Organic Nitrogen
- Phenolics (ug/l)
- Toxaphene (ug/l)
- 2, 4-D (ug/l)
- 2, 4, 5-T (ug/l)
- 3, 4, 5-TP Silvex (ug/l)

RADIOACTIVE

- Gross Alpha (pCi/l)
- Gross Beta (pCi/l)
- Radium 226 (pCi/l)
- Thorium 230 (ug/l)
- Uranium (ug/l)

MISCELLANEOUS

- Alkalinity
- Color (PCU)
- Oxidation Reduction Potential (ORP) (mV)
- Dissolved Oxygen
- Fecal Coliform Bacteria (#/100ml)
- Fecal Streptococcal Bacteria (#/100ml)
- Hardness (Calcium, Magnesium, and Total)
- Odor (TO)
- pH
- Specific Conductance (umhos/cm)
- Temperature (C)
- Turbidity (NTU)

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[1] Wells FIF-1, FIS-3, and PT-2 on Figure 6-28.

[2] All parameters to be reported in mg/l unless otherwise noted.

Table 6-7. STATISTICAL SUMMARY OF GROUNDWATER QUALITY DATA FOR SELECTED WELLS IN THE SURFICIAL AQUIFER ON THE FARMLAND INDUSTRIES, INC. PROPERTY IN HARDEE COUNTY, FLORIDA.

	PT-1[3]				PT-2[3]			
Parameter[1]	$\overline{X}$[2]	S.D.	Min.	Max.	$\overline{X}$	S.D.	Min.	Max.
Temperature (°C)	22.5	1.2	20.5	24.6	24.5	1.6	22.3	27.5
pH (std. units)	5.5	0.2	5.07	5.9	5.6	0.3	5.1	6.3
Conductivity (µmhos/cm)	101	29	70	155	95	18	73	124
Total Dissolved Solids	67	19	36	104	60	12	45	93
Total Suspended Solids	14	20	1.0	73	7	9	1.7	38
Total Alkalinity as $CaCO_3$	33	26	12	111	17	8.5	3.7	31
Total Hardness as $CaCO_3$	44	15	28	72	38	7	28	50
Calcium	11	3	6.9	16	8.9	1.8	7.0	12
Magnesium	3.7	1.7	1.9	7.1	2.9	1.0	1.6	4.7
Sodium	4.9	0.7	4.3	7.0	6.1	4.5	4.3	21
Potassium	0.42	0.24	0.29	1.20	0.60	0.22	0.35	1.19
Iron	1.16	0.42	0.13	2.00	2.04	0.64	0.24	2.79
Silica	2.7	0.6	1.8	4.2	4.6	1.1	3.0	7.0
Sulfate	3.6	1.4	2.2	6.8	11	2.5	7.4	17
Chloride	13	8.4	9.2	42	11	1.9	8.5	14
Fluoride	0.34	0.12	0.02	0.47	0.40	0.17	0.02	0.60
Bicarbonate	42	32	21	136	22	11	4.5	38
Nitrate	0.26	0.36	<0.01	1.34	0.14	0.14	0.01	0.51
Phosphate	1.21	0.95	<0.01	4.27	0.53	0.22	0.06	0.80
Hydrogen Sulfide	0.49	0.16	0.10	0.72	0.28	0.19	0.10	0.70
Radium-226 (pCi/l)	0.5	0.4	0.1	1.1	0.5	0.1	0.3	0.6
Gross Alpha (pCi/l)								
Dissolved	43.4	26.7	6.6	81.6	69.3	37.3	19.7	115.4
Suspended	3.7	2.7	1.8	8.4	3.8	2.1	2.1	7.3

[1] All units in mg/l unless otherwise noted.

[2] Abbreviations:

$\overline{X}$ = mean.
S.D. = Standard Deviation.
Min. = Minimum Value Determined.
Max. = Maximum Value Determined.

[3] Data for PT-1 and PT-2 are based on 14 monthly samples between June 1977 and July 1978.

Table 6-8. ANALYSES OF GROUNDWATER FROM THE SECONDARY ARTESIAN AND FLORIDAN AQUIFERS.

Parameters[1]	Secondary Artesian Aquifer (FIS-1)		Floridan Aquifer (FIF-1)			
Sampling Date:	7/12/77	7/15/77	10/4/77	10/14/77	10/21/77	10/24/77
Temperature (°C)	26.0	25.5	30.2	29.2	-	29.5
pH (std. units)	7.62	7.5	7.2	7.3	-	7.5
Conductivity (μmhos/cm)	465	460	570	580	580	590
Total Dissolved Solids	307	319	371	366	371	370
Total Suspended Solids	87	5.0	0.0	0.0	0.0	0.0
Total Alkalinity as $CaCO_3$	174	152	136	147	148	147
Total Hardness as $CaCO_3$	206	200	246	252	249	247
Calcium	41	39	51	58	57	56
Magnesium	25	25	29	26	26	26
Sodium	27	25.7	9.2	9.0	9.2	9.2
Potassium	3.0	3.0	0.19	1.99	2.02	2.03
Iron	0.26	0.07	0.03	0.02	0.01	<0.01
Silica	23	18	10	9.0	10	10
Sulfate	45	45	100	100	100	100
Chloride	21.3	20.7	11	11	11	12
Fluoride	3.0	2.8	0.25	0.25	0.25	0.25
Bicarbonate	212	185	165	179	180	179
Nitrate	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Phosphate	0.136	0.03	<0.01	<0.01	<0.01	<0.02
Hydrogen Sulfide	1.20	1.64	2.9	3.2	3.1	3.1
Radium-226 (pCi/ℓ)[2]	16.0(7/77)	15.2(2/78)	6.7(10/77)	2.5(10/77)	1.9(2/78)	13.9(7/78)
Gross Alpha (pCi/ℓ)[2]						
Dissolved	11.1(7/77)	12.1(2/78)	<3.7(7/77)	<2.6(10/77)	<1.0(2/78)	9.3(7/78)
Suspended	6.2(7/77)	<3.5(2/78)	<3.1(7/77)	<1.0(10/77)	<2.6(2/78)	<6.0(7/78)

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[1] All units in mg/ℓ unless otherwise noted.
[2] Radiologic samples were taken on dates shown in parentheses.

Source: P.E. LaMoreaux & Associates, Inc. (1978).

Table 6-9. STATE AND FEDERAL DRINKING WATER STANDARDS AND CRITERIA

Parameters[1]	Florida Water Supply Standards	National Interim Primary Drinking Water Regulations	U.S. EPA Water Quality Criteria
Chloride	250	-	-
Fluoride	0.8	1.4	-
Hydrogen Sulfide	-	-	0.05
Iron	0.30	-	0.30
Nitrate	10	10	10
pH (std. units)	-	-	5.0-9.0
Sulfate	250	-	-
Total Dissolved Solids	500	-	-
Gross Alpha (pCi/ℓ)	-	15	-
Radium-226 (pCi/ℓ)	-	5	-

[1] All units in milligrams/liter unless otherwise noted.

Source: Florida Administrative Code (Chapter 17-22); National Interim Primary Drinking Water Regulations (40 CFR 141); US EPA Quality Criteria for Water. 1976.

Table 6-10. A COMPARISON OF THE WATER QUALITY OF THE SURFICIAL AQUIFER AND SLIME SUPERNATANT.

Constituents[1]	Surficial Aquifer[2]	Slime Supernatant[3]
pH, pH units	5.6	7.8
Specific Conductance, µmhos/cm	98.	523.
Total Dissolved Solids	64.	348.
Calcium	10.	57.
Magnesium	3.3	22.
Sodium	5.5	18.
Potassium	0.51	1.3
Bicarbonate	32.	112.
Sulfate	7.3	144.
Chloride	12.	17.
Iron	1.6	0.119
Silica	3.7	2.5
Fluoride	0.37	2.0
Nitrate, as N	0.20	1.06
Phosphorus, as PO_4	0.87	0.273
Radium-226, pCi/l	0.5	0.67

[1] Units are mg/l unless otherwise noted.
[2] Average of analyses from PT-1 and PT-2 (June 1977 to July 1978).
[3] Lamont, et al. 1975. Characterization Studies of Florida Phosphate Slimes.

Source: U.S. Environmental Protection Agency. 1979.

7.0
SURFACE WATER

7.1 THE AFFECTED ENVIRONMENT

7.1.1 SURFACE WATER QUANTITY

The occurrence and availability of surface water is determined by a cyclic exchange of water between the earth and the atmosphere known as the hydrologic cycle. Surface water accumulates from precipitation and from groundwater flow that intercepts the earth's surface. It may return to the atmosphere by evaporation and transpiration or it may seep into the earth and recharge groundwater supplies.

REGIONAL CHARACTERISTICS

The Farmland mine site is located in a typical area of the Coastal Lowlands physiographical region. The Coastal Lowlands Region in this area extends from the Gulf of Mexico to the Central Highlands Region, about 20 miles west of the site. It consists of low, nearly level plains; gently undulating to rolling areas with numerous intermittent ponds, swamps and marshes; sinkholes with many lakes; and perennial streams (EPA 1978a). The site contains swamps, marshes, and intermittent and perennial streams. Elevations onsite range from 35 to 100 feet above mean sea level (MSL) (PELA 1979b). Regional highs of about 300 feet MSL exist in the Central Highlands Region.

The distribution and circulation of water in the atmosphere, on the land surface, and in the soil and underlying rocks of the Farmland site are typical of the Middle Gulf Hydrologic System as described by Cherry, et al. (1970). This well established hydrologic pattern is a result of the semi-tropical climatological regime, the very flat relief, the unconsolidated surficial deposits, and the limestone and dolomite geologic formations of the region. It is characterized by an average annual rainfall of about 55 inches (EPA 1979a), an average annual evapotranspiration of 39 inches, an average annual total surface runoff of 15 inches, and an annual aquifer recharge of between 1/2 and 5 inches. Approximately 60 percent of the total annual average precipitation results from thunderstorms during the months of June, July, August, and September. These intense storms of relatively short duration saturate the surface soils, raise the water table to the land surface at many places, rapidly increase stream discharges, and occasionally cause some local flooding. The rains during the remainder of the year are generally widely spaced with respect to time of occurrence and are of the gentle frontal type. During this period the water table normally drops 6 to 8 feet. Some streams go dry. Much of the flow in the others is limited to baseflow that drains from the unconfined aquifer. The amount of baseflow ranges from 14 to 20 percent of the total yearly runoff.

Average annual rainfall in Hardee County is 54 inches (Hughes, et al. 1971); however, the annual rainfall as measured by the U.S. National Weather Service at the Cattle Range Experiment Station 6 miles SSW of Ona (Figure 7-1) and other regional stations indicates a below normal trend for the period 1961 through 1977 (Figure 7-2). Long-term rainfall patterns which deviate significantly from the normal affect aquifer levels and the entire hydrologic system. Monthly rainfall measurements from June 1977 to August 1978 for the three onsite stations (Figure 7-1) and monthly normals for period 1941 through 1970 are given in Table 7-1.

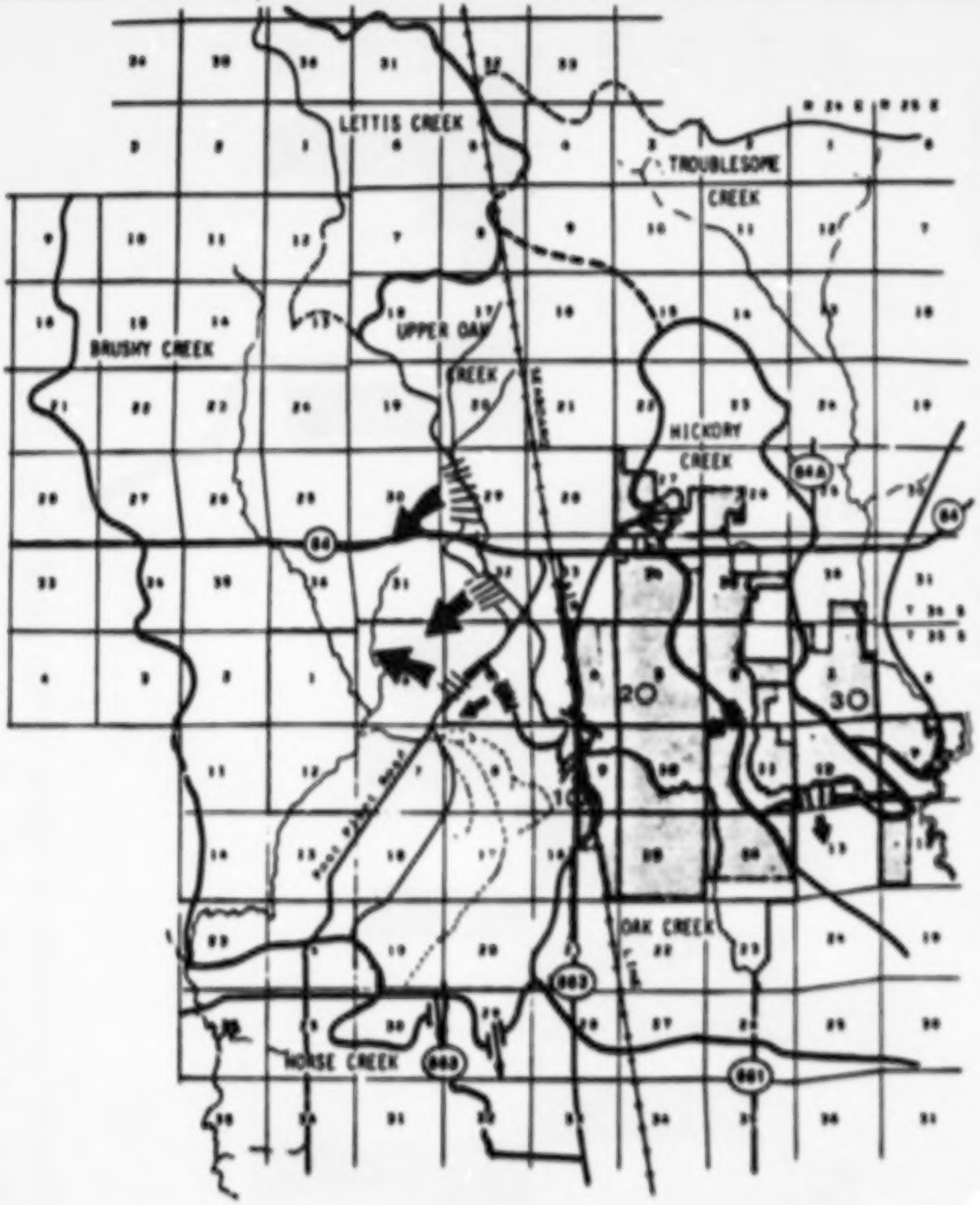

LETTIS CREEK
TROUBLESOME CREEK
BRUSHY CREEK
UPPER OAK CREEK
HICKORY CREEK
64A
64
20
30
1
OAK CREEK
HORSE CREEK
862
863
861
RAIN GAUGE STATIONS
N
SCALE IN MILES

FIGURE 7-1. RAIN GAUGE STATIONS AND DRAINAGE BOUNDARIES OF STREAMS ON AND ABUTTING FARMLAND INDUSTRIES, INC. PROPERTY.

SOURCE: FARMLAND INDUSTRIES, INC., DRI, JUNE 1979.

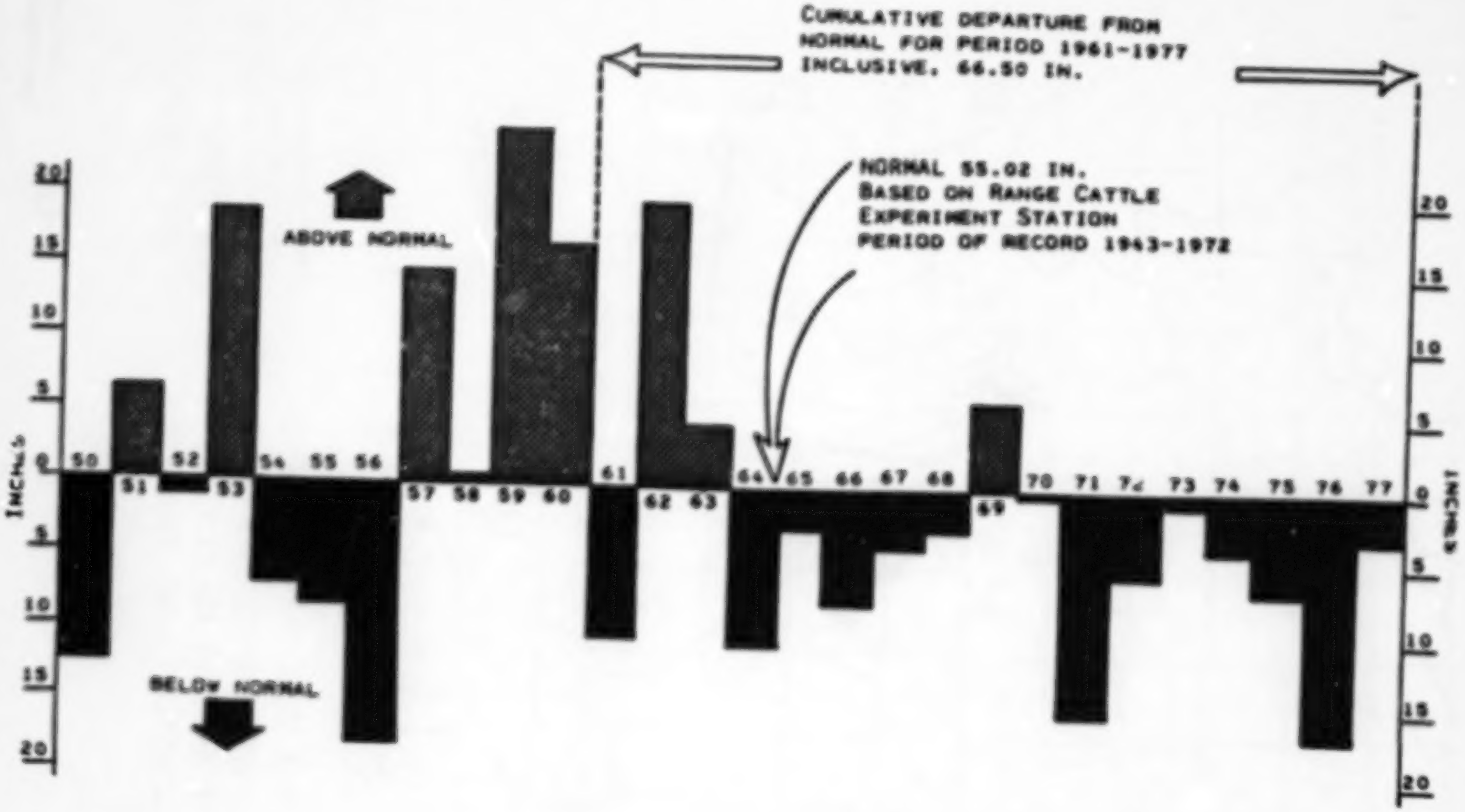


FIGURE 7-2. TOTAL PRECIPITATION AND DEPARTURES FROM NORMAL FOR RANGE CATTLE EXPERIMENT STATION 6 MILES SSW OF ONA, FLORIDA.

SOURCE: FARMLAND INDUSTRIES, INC., DRI, JUNE 1979

DESCRIPTION OF SURFACE WATER ONSITE

Most of the Farmland property lies within portions of the drainage basins of Troublesome, Hickory, and Oak Creeks, which are all tributaries of the Peace River. The drainage divides are somewhat higher areas that separate runoff into different basins (Figure 7-1). About 4 percent of the site adjoins and drains directly into the Peace River. The premining drainage areas and average annual flows are listed in Table 7-2. Large portions of each drainage basin do not drain well and are classified as wetlands (Figure 7-3).

Troublesome Creek

The northeast part of the property drains into Troublesome Creek. The creek has a relatively well defined channel and was the only stream onsite to flow throughout the 1977 dry season (PELA 1979b). The area drains fairly well and the portion on the Farmland property contains a smaller percentage of wetlands than any other drainage. A man-made channel joins the natural stream from the west in Section 1, T35S R25E. The channel slope of Troublesome Creek averages 10 feet/mile.

Hickory Creek

The central part of the property is in the Hickory Creek drainage basin. It is characterized in most places by a narrow, deeply incised channel with a channel slope of approximately 10 feet/mile. Flooding is generally of short duration with little deposition of sediment outside the channel (PELA 1979b). In the extreme northern part of the mine site, Hickory Creek may overflow its basin boundaries during major storms, and some of the flow originating in Hickory Creek north of the site drains into Oak Creek. The soils in the Hickory Creek basin are fairly well drained and the area has only a few wetlands.

Oak Creek

The western half of the mine property is in the Oak Creek drainage basin. The basin is poorly drained with a channel slope of about 5

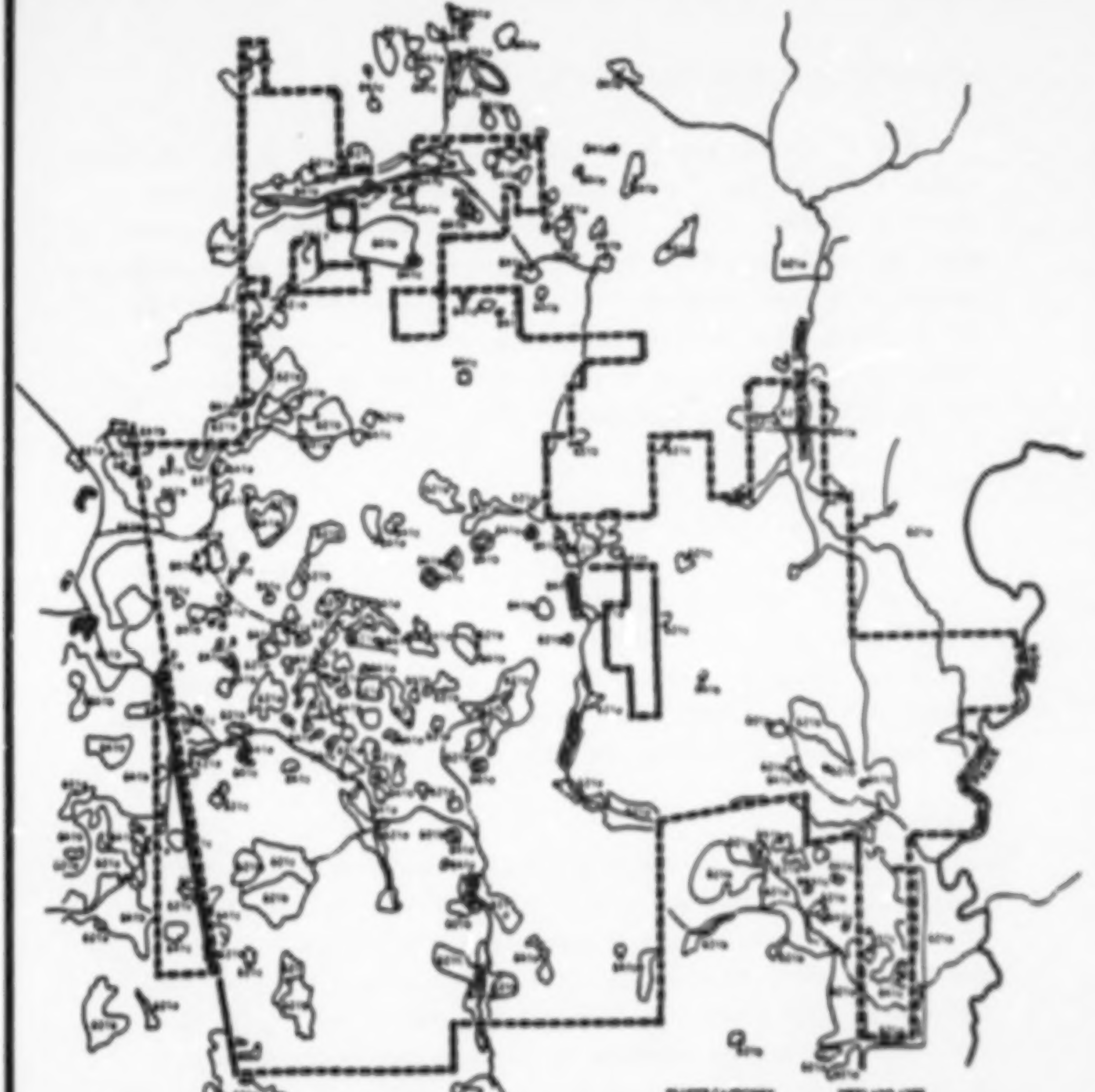

FLUCCS CATEGORY
WETLAND TYPE
621
FRESHWATER SWAMP (LEVEL III)
621 A
RIVER, CREEK, AND LAKE OVERFLOW AREAS
621 B
BOGS AND BAYHEADS
621 C
INLAND PONDS AND SLOUGHS
641
FRESHWATER MARSH
641 A
SAWGRASS MARSH
641 B
CATTAIL, BULRUSH, MAIDENCANE MARSH
641 C
WET PRAIRIE
ISOLATED UPLAND AREAS
N
0
2,000
4,000
SCALE IN FEET

FIGURE 7-3. WETLAND AREAS.

SOURCE: FARMLAND INDUSTRIES, INC., DRI, JUNE 1979

feet/mile. It contains numerous swamps and marshes, especially in the northern and the Oak Creek Islands areas. The only two wetlands on the mine property to retain standing water throughout the 1977 and 1978 dry seasons are in the northern part of this drainage basin. With the recent extended period of below normal rainfall, the flow pattern through the Oak Creek Islands area has shifted to a well-defined channel along the southern edge of the islands.

Oak Creek, however, is not a natural drainage basin (Figure 7-1). The area shown as Oak Creek west of State Road 663 did not always drain toward Oak Creek. It originally drained into Brushy Creek. Most of the flood flow in this area still flows to Horse Creek through Brushy Creek. There are at least three distributaries from the Upper Oak Creek area. The Oak Creek channel south of State Road 64 passing under the Post Plant Road and State Road 663 has been diverted from the original drainage boundaries to drain this land through the Oak Creek Islands area.

Peace River

The creeks which drain the Farmland property ultimately flow into the Peace River. A small portion of the eastern edge of the mine property borders the Peace River. Most of the Farmland property that drains directly to the river and part of the lower reaches of the Troublesome Creek drainages are inside the Peace River floodplains.

STREAMFLOW

PELA (1978) present streamflow data from the Farmland site over the period June 1977 through August 1978 (Table C-1 thru C-6 in Appendix C). Hydrographs produced from these data are presented in Figures 7-4 through 7-8. However, streamflow (like precipitation) is quite variable. Thus statistically determined values of average, low, and flood flows were determined. Such determinations improve with an increase in

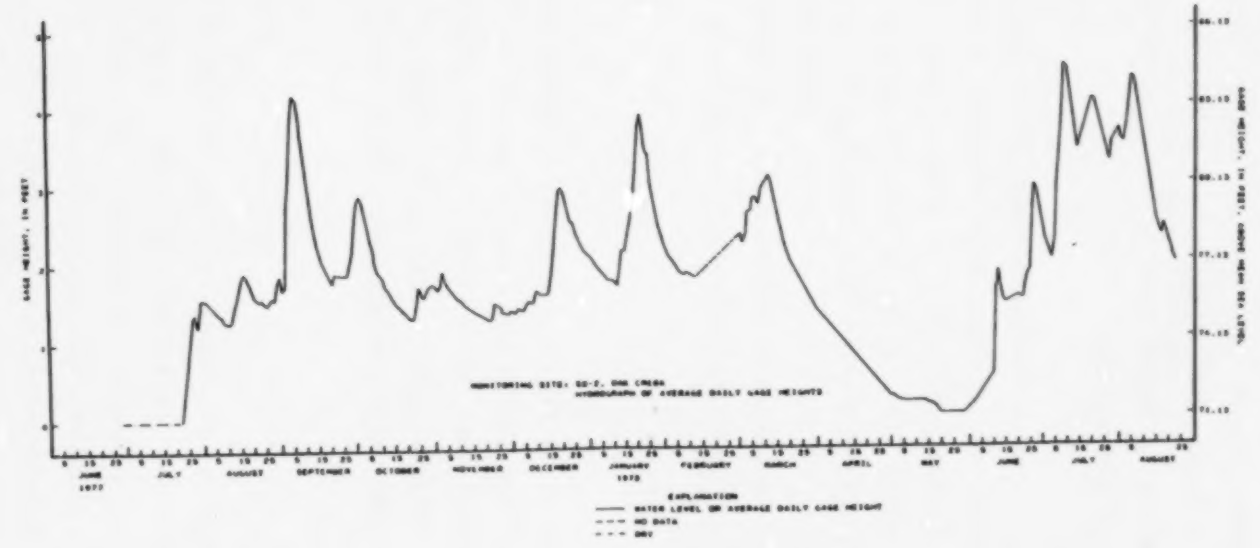


FIGURE 7-4. HYDROGRAPH OF AVERAGE DAILY GAUGE HEIGHTS AT STATION SW-2 (OAK CREEK) ON THE FARMLAND INDUSTRIES, INC. MINE PROPERTY IN HARDEE COUNTY, FLORIDA; JUNE 1977 - AUGUST 1978.

SOURCE: P.E. LA MOREAUX & ASSOCIATES, INC. (1978)

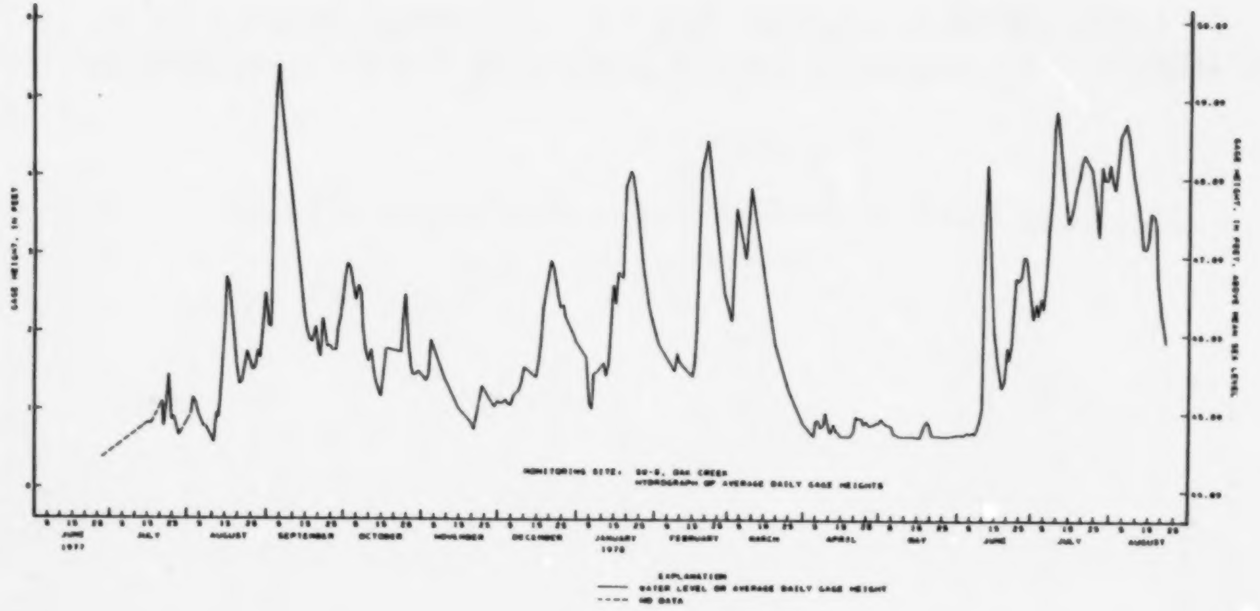


FIGURE 7-5. HYDROGRAPH OF AVERAGE DAILY GAUGE HEIGHTS AT STATION SW-8 (OAK CREEK) ON THE FARMLAND INDUSTRIES, INC. MINE PROPERTY IN HARDEE COUNTY, FLORIDA; JUNE 1977 - AUGUST 1978.

SOURCE: P.E. LA MOREAUX & ASSOCIATES, INC. (1978)

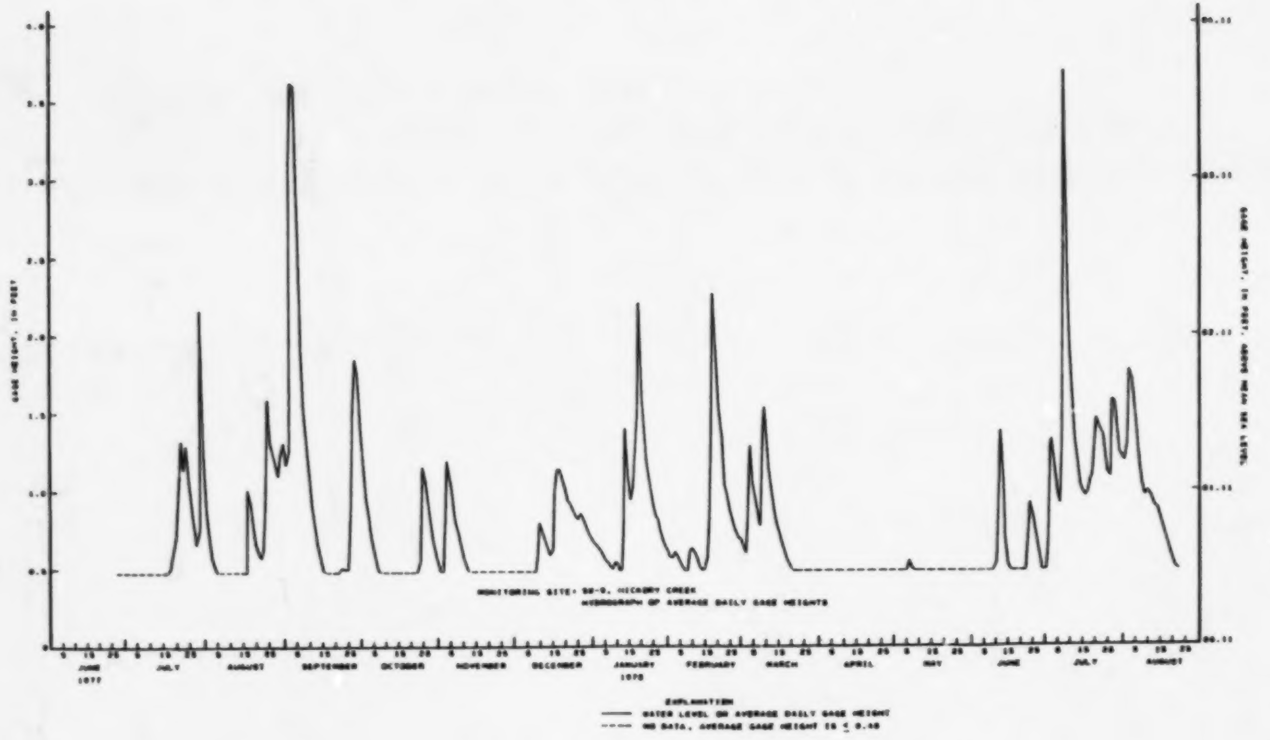


FIGURE 7-6. HYDROGRAPH OF AVERAGE DAILY GAUGE HEIGHTS AT STATION SW-9 (HICKORY CREEK) ON THE FARMLAND INDUSTRIES, INC. MINE PROPERTY IN HARDEE COUNTY, FLORIDA; JUNE 1977 - AUGUST 1978.

SOURCE: P.E. LA MOREAUX & ASSOCIATES, INC. (1978)

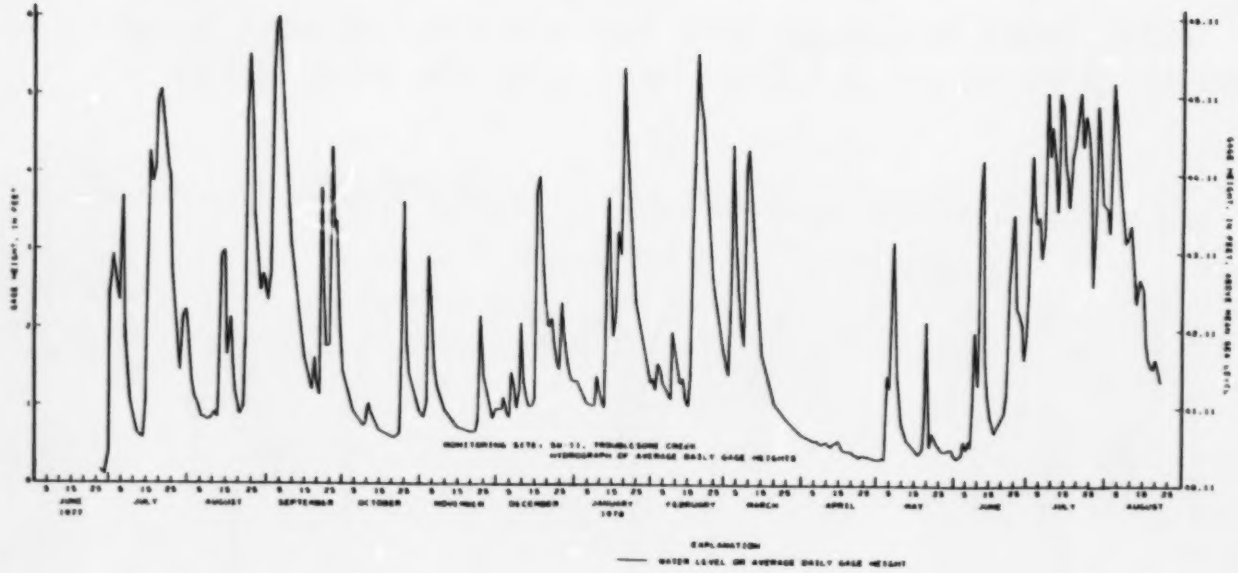


FIGURE 7-7. HYDROGRAPH OF AVERAGE DAILY GAUGE HEIGHTS AT STATION SW-11 (TROUBLESOME CREEK) ON THE FARMLAND INDUSTRIES, INC. MINE PROPERTY IN HARDEE COUNTY, FLORIDA; JUNE 1977 - AUGUST 1978.

SOURCE: P.E. LA MOREAUX & ASSOCIATES, INC. (1978)

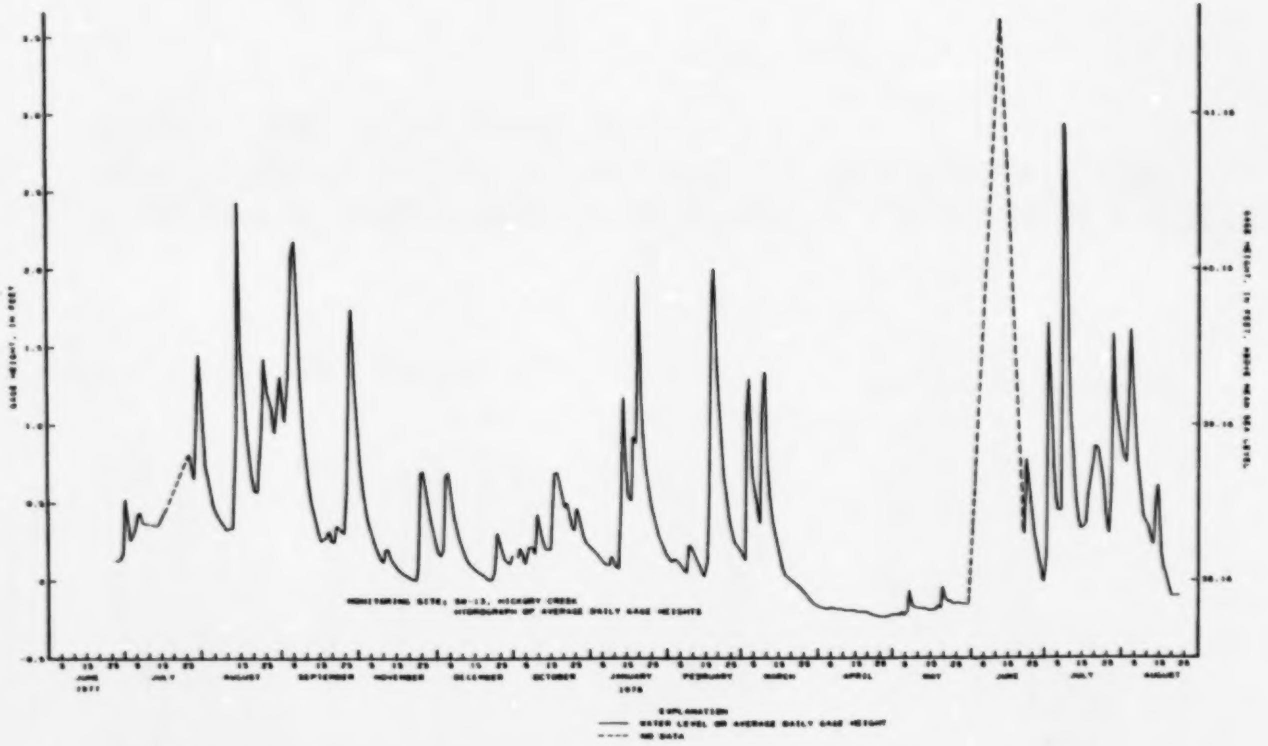


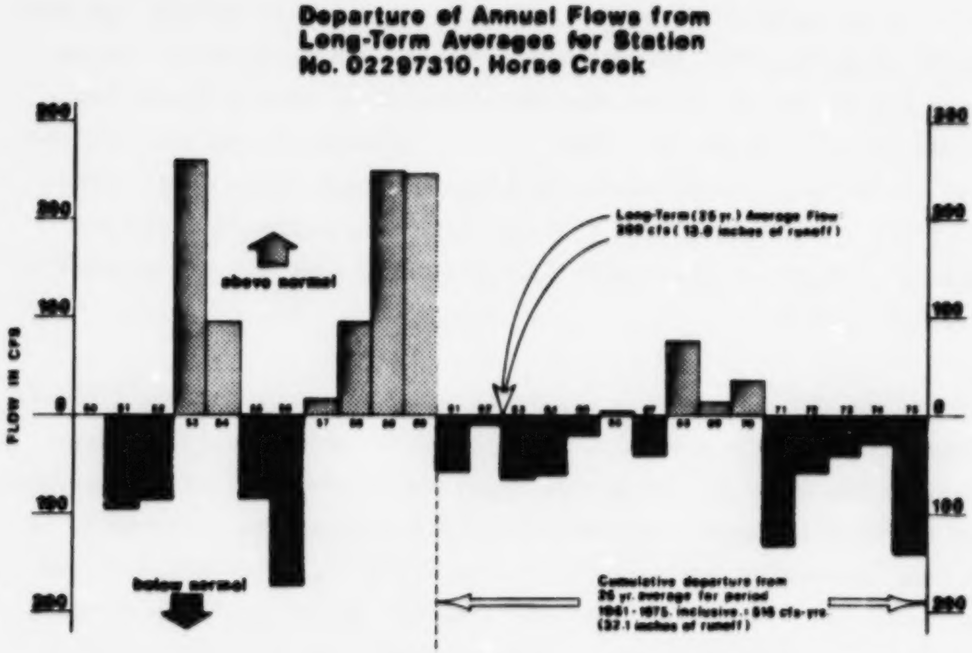
FIGURE 7-8. HYDROGRAPH OF AVERAGE DAILY GAUGE HEIGHTS AT STATION SW-13 (HICKORY CREEK) ON THE FARMLAND INDUSTRIES, INC. MINE PROPERTY IN HARDEE COUNTY, FLORIDA; JUNE 1977 - AUGUST 1978.

SOURCE: P.E. LA MOREAUX & ASSOCIATES, INC. (1978)

the period of record. Stream gauging stations on the Farmland mine property (Figure 7-1) were monitored between June 1977 and August 1978--too short a period to have statistical value. The closest gauging station on a stream whose drainage is somewhat similar to the ones on the site is on Horse Creek near Arcadia, Florida. This station has been monitored since May 1950 (Figure 7-9). Based upon correlations in the fluctuations of the onsite streams and Horse Creek during the period from June 1977 to August 1978 (PELA 1979b), average streamflows for the streams on the site can be estimated from the Horse Creek data. Long-term average discharges (Table 7-3) are based on estimated long-term averages of 0.9 to 1.1 cfs/square mile which are commonly experienced in the area (PELA 1979b).

Low flows for Horse Creek were determined by a Log-Pearson Type III frequency distribution analysis. They are 1.07 and 0.07 cfs, respectively, for the 2-yr and the 10-yr, 7-day low flows. All of the streams on the Farmland property, except Troublesome Creek, were observed to be dry during the spring and fall of 1977 and 1978. Thus, their 2-yr and 10-yr, 7-day low flow is 0. The low-flows estimated for Troublesome Creek are 0.4 cfs for the 2-yr, 7-day low; and 0.04 cfs for the 10-yr, 7-day low flow.

Flood flow estimates for the streams on the Farmland property (Table 7-4) were made by applying drainage basin parameters of area, main channel slope, and storage to an equation developed from flow data collected from 15 gauged streams in the Florida phosphate region. The records from these 15 streams comprise 439 station years of published peak flows through the 1976 water year. The annual maximum flow data for each gauging station were analyzed statistically using a Log-Pearson Type III distribution. Flood flows for recurrence intervals of 2, 5, 25, and 100 years (Figure 7-10) were calculated (PELA 1979b). The calculated flood flows for each gauging station were regressed against



Departure of Annual Flows from Long-Term Averages for Station No. 02297310, Horse Creek

Long-Term (25 yr.) Average Flow: 300 cfs (13.8 inches of runoff)

Cumulative departure from 25 yr. average for period 1961-1975, inclusive.: 516 cfs-yrs (32.1 inches of runoff)

FIGURE 7-9. DEPARTURE OF ANNUAL FLOWS FROM LONG-TERM AVERAGES FOR STATION NO. 02297310, HORSE CREEK.

SOURCE: MISSISSIPPI CHEMICAL CORPORATION, DRI, 1976

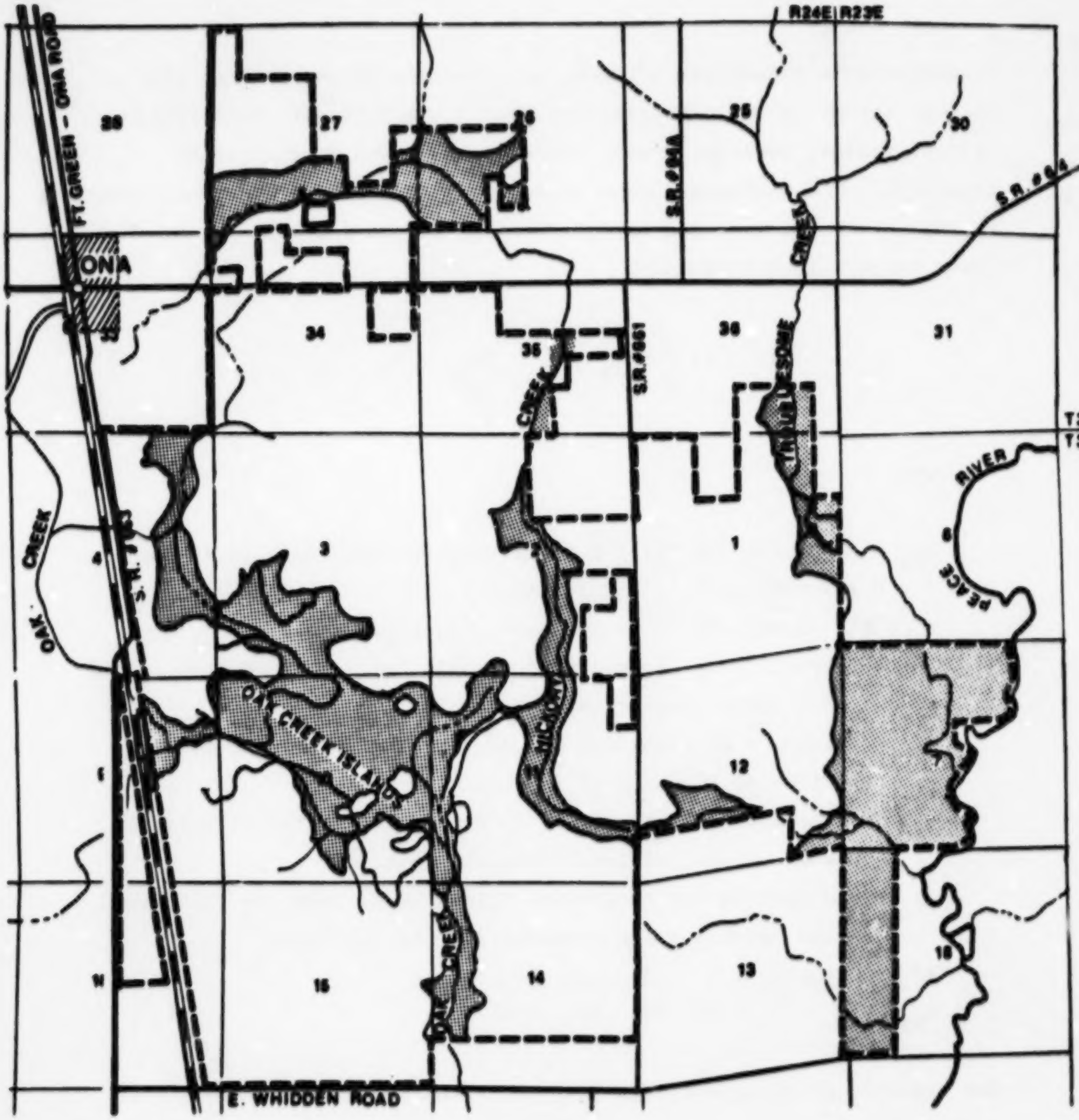

R24E|R23E
FT. GREEN - ONA ROAD
ONA
28
27
26
25
30
S.R. #664A
CREEK
S.R. #64
33
34
35
36
31
S.R. #661
CREEK
TROUBLESOME
T34S
T35S
RIVER
PEACE
6
1
3
4
OAK CREEK
S.R. #663
OAK CREEK ISLANDS
HICKORY
12
9
16
15
OAK CREEK
14
13
18
E. WHIDDEN ROAD

FIGURE 7-10. EXISTING FLOODPLAINS.

▨ 100-YEAR FLOODPLAIN

0 2,000 4,000

SCALE IN FEET

SOURCE: FARMLAND INDUSTRIES, INC., HARDEE COUNTY MASTER PLAN, JUNE 1979

drainage basin parameters of area, main channel slope, storage elevation, forest cover, precipitation, basin shape (L^2/A), soil infiltration factor, geology, annual precipitation, and precipitation intensity. The following flood equation was determined from the results of this study and was used for all streams on the property except in lower Brushy Creek tributary.

$$Q_{RT} = C_{RI} \frac{A^{n} S^{0.2}}{s_t^{0.4}}$$

where

Q_{RI} = Flood flow in CFS for recurrence interval (RI) in years.
A = Drainage area in square miles.
n = $(0.12/A+0.12)^{0.05}$ = drainage area coefficient.
S = Slope of main channel in feet/mile between point of 0.1L and 0.85L above gauging station.
L = Length of main channel in miles measured from the gauging station to the head of the basin.
s_t = Percent of drainage basin in depression storage (lakes, swamps, sinks, dolines, hammocks, etc.).
C_{RI} = Coefficient for recurrence intervals RI from the following table (median value computed for the 16 sites).

RI	(Years)	2	5	25	100
C_{RI}		108	230	497	856

The standard error of estimate (SE) achieved for each recurrence interval was 29 percent.

7.1.2 SURFACE WATER QUALITY

REGIONAL DESCRIPTION

The Farmland site lies within the Peace River Basin (Figure 7-11). The water quality of the Peace River, as well as others in the region,

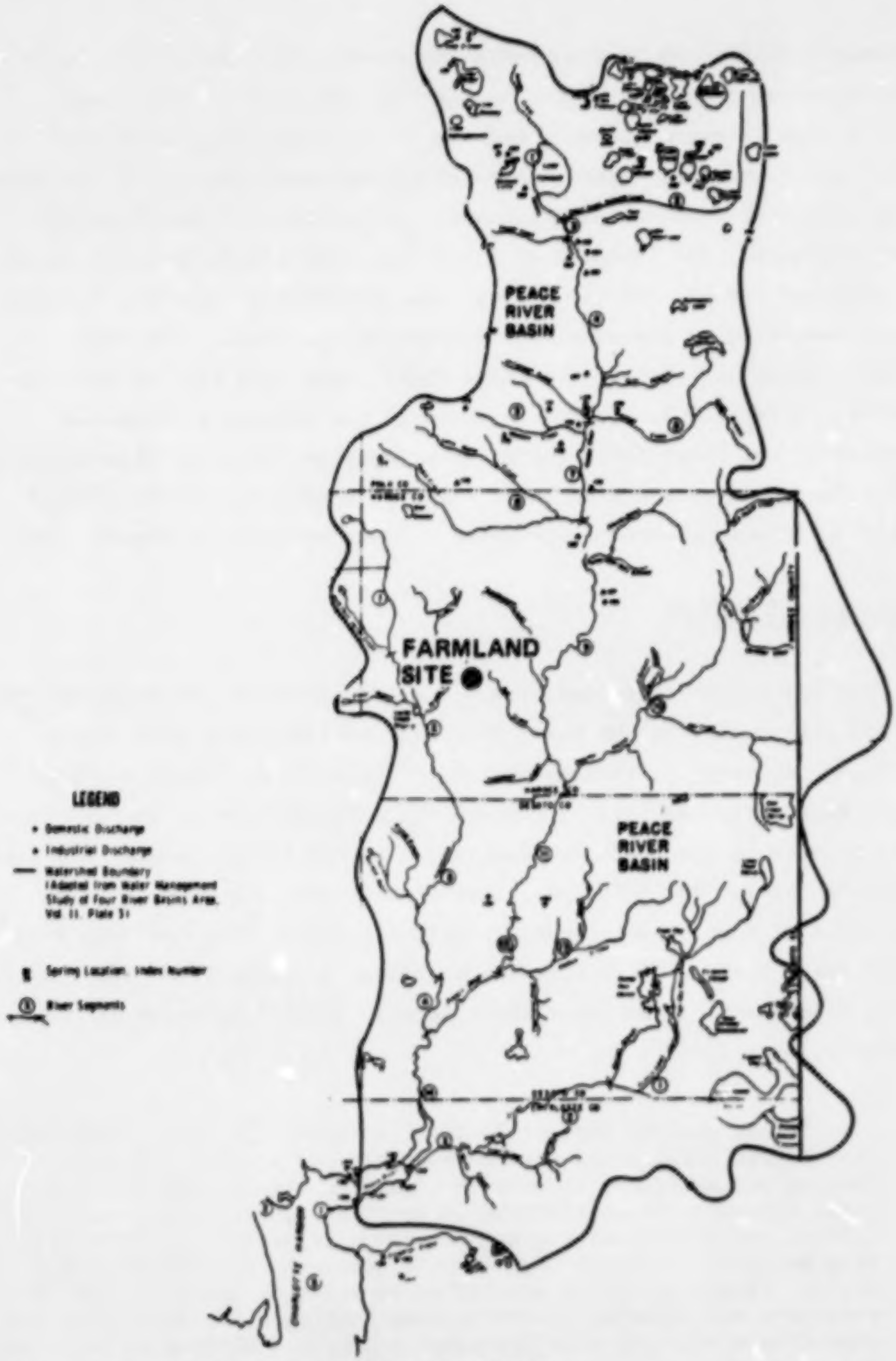

PEACE RIVER BASIN
FARMLAND SITE
PEACE RIVER BASIN
LEGEND
• Domestic Discharge
▲ Industrial Discharge
Watershed Boundary (Adapted from Water Management Study of Four River Basins Area, Vol. II, Plate 3)
Spring Location, Index Number
① River Segments

FIGURE 7-11. PEACE RIVER BASIN, FLORIDA.

SOURCE: U.S. ENVIRONMENTAL PROTECTION AGENCY, CENTRAL FLORIDA PHOSPHATE INDUSTRY AREAWIDE IMPACT ASSESSMENT PROGRAM; VOLUME V - WATER, SEPTEMBER 1978.

is greatly influenced by flow--with higher dissolved solids and ionic concentrations occurring in the October-May dry period. The Peace River's flow is quite variable because of the relatively large contribution of overland runoff. Also affecting water quality in the Peace River are: (1) releases of pollutants into streams or lakes through point discharge, (2) failures of retaining dikes around treatment ponds, (3) overland runoff, and (4) inflow from contaminated aquifers hydraulically connected to the streams and lakes of the basin. The characteristic water quality for the Peace River Basin from 1970 to 1976 is provided in Table 7-5. Table 7-6 presents the results of chemical analyses of the Peace River during relatively low and high discharges in 1965. The analyses are from Toler (1967), as reported by EPA (1978a); sample locations referred to in Table 7-6 are provided in Figure 7-12.

SITE AREA DESCRIPTION

The watersheds contained within the boundaries of the Farmland site are all tributaries to the Peace River and include, from east to west, the following creeks: Troublesome, Hickory, and Oak. Smith and Gillespie Engineers, Inc. (1977) discuss the water quality of Hardee County as it relates to the Draft 201 Facility Plan for Hardee County. As part of the background for this Plan, they present the frequency at which violations of surface water quality criteria (Class III) have occurred in the Peace River. These data are presented in Table 7-7. The following discussion of the Peace River is also taken from Smith and Gillespie, Inc. (1977):

> "Water quality segment 25.2BA-2 includes the Peace River and its smaller tributaries between Wauchula and Arcadia. Water quality was monitored at nine locations in this segment and indicates excessive concentrations of phosphates, fluorides, and nitrate and nitrite nitrogen. Occasionally excessive values have been measured for turbidity, ammonia nitrogen, and coliform bacteria. Phosphate mining activities in upstream areas account for phosphate and fluoride concentrations; nitrogen concentrations may come from either point or non-point sources. Coliform bacteria may come directly from sewage treatment plant discharges or from septic

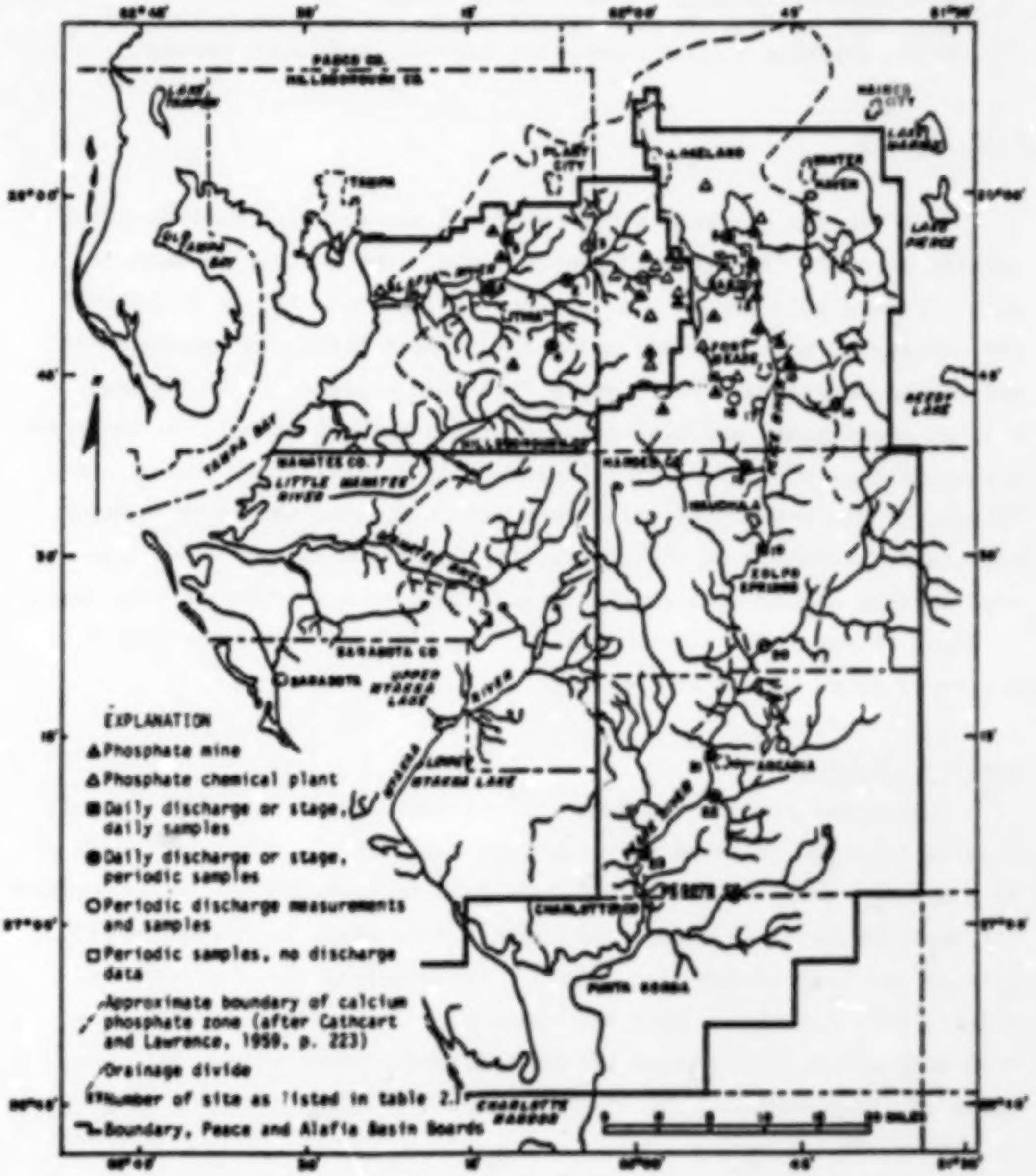

PASCO CO.
HILLSBOROUGH CO.
LAKE TARPON
TAMPA
PLANT CITY
LAKELAND
HAINES CITY
WINTER HAVEN
LAKE PIERCE
OLD TAMPA BAY
FORT MEADE
REEDY LAKE
TAMPA BAY
MANATEE CO.
LITTLE MANATEE RIVER
MANATEE RIVER
HARDEE CO.
WAUCHULA
ZOLFO SPRINGS
SARASOTA CO.
SARASOTA
UPPER MYAKKA LAKE
LOWER MYAKKA LAKE
MYAKKA RIVER
ARCADIA
PEACE RIVER
DE SOTO CO.
CHARLOTTE CO.
PUNTA GORDA
CHARLOTTE HARBOR
EXPLANATION
▲ Phosphate mine
△ Phosphate chemical plant
■ Daily discharge or stage, daily samples
● Daily discharge or stage, periodic samples
○ Periodic discharge measurements and samples
□ Periodic samples, no discharge data
Approximate boundary of calcium phosphate zone (after Cathcart and Lawrence, 1959, p. 223)
Drainage divide
Number of site as listed in table 2.1
Boundary, Peace and Alafia Basin Boards
82°45'
30'
15'
82°00'
45'
81°30'
28°00'
45'
30'
15'
27°00'
26°45'
0
5
10
15
20 MILES

FIGURE 7-12. LOCATION OF SAMPLING SITES ON STREAMS AND AREAS OF PHOSPHATE MINING AND PROCESSING.

SOURCE: U.S. ENVIRONMENTAL PROTECTION AGENCY, CENTRAL FLORIDA PHOSPHATE INDUSTRY AREAWIDE IMPACT ASSESSMENT PROGRAM; VOLUME V - WATER, SEPTEMBER 1978.

> tank influence in the populated but unsewered areas near Wauchula. This segment receives waters from a large area of Peace River drainage, and can be expected to receive a continuing influence from phosphate mining, non-point sources, and human wastes."

SITE STUDIES

This section presents a discussion of the existing surface water quality data for the Farmland project site. The quality of surface waters on and adjacent to the Farmland project site can be attributed to the effects of both on-going natural processes and local agricultural and mining practices. For example, seasonal changes in streamflow, weather conditions, and biological activity tend to affect the in-stream concentrations of various constituents. Agricultural and mining operations, on the other hand, often can act as a major source of certain pollutant loadings. In particular, fertilization practices and the construction of drainage canals contribute to the nutrient levels found in local streams. No significant municipal sources of water pollution are to be found in the project area.

Sampling Programs

During the period from June 1977 to June 1978 (PELA 1978), waters flowing from the Farmland property were monitored on a monthly basis at 14 sampling stations (Tables D-1 thru D-14 in Appendix D). All sampling and analyses for this effort were done for Farmland by Environmental Science and Engineering, Inc. (ESE). The stations for the sampling efforts were located so that the quality of each stream was monitored both upstream and downstream of the proposed project site. The locations of these stations are shown in Figure 7-13 and can be described, by stream, as follows:

- Peace River - Stations SW-15 and SW-16.
- Troublesome Creek - Stations SW-11 and SW-12.
- Hickory Creek - Stations SW-4, SW-9, SW-13, and SW-14.
- Oak Creek - Stations SW-2, SW-6, SW-7, and SW-8.
- Marsh/Ditch systems - Stations SW-1 and SW-2.

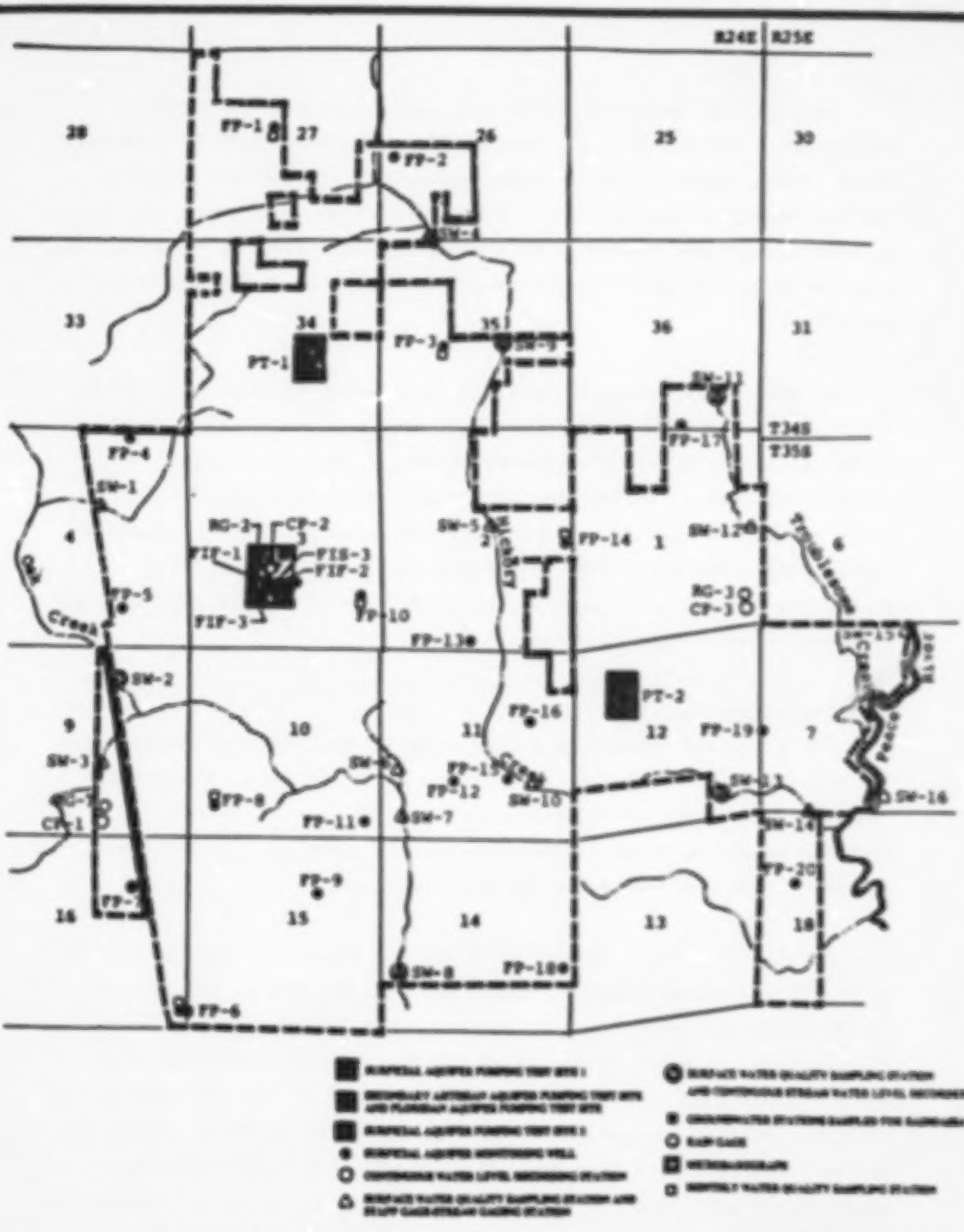

R24E
R25E
T34S
T35S
28
27
26
25
30
33
34
35
36
31
4
3
2
1
6
9
10
11
12
7
16
15
14
13
18
FP-1
FP-2
SW-4
PT-1
FP-3
SW-9
SW-11
FP-17
FP-4
SW-1
RG-2
CP-2
FIF-1
FIS-3
FIF-2
FIF-3
SW-5
FP-14
SW-12
Oak Creek
FP-5
FP-10
FP-13
RG-3
CP-3
Troublesome Creek
SW-15
South Creek
SW-2
PT-2
FP-16
FP-19
Peace
SW-3
SW-6
FP-15
FP-12
Creek
SW-10
SW-13
SW-16
RG-1
CP-1
FP-8
FP-11
SW-7
SW-14
FP-9
FP-7
FP-20
SW-8
FP-18
FP-6
SURFICIAL AQUIFER PUMPING TEST SITE 1
SECONDARY ARTESIAN AQUIFER PUMPING TEST SITE AND FLORIDAN AQUIFER PUMPING TEST SITE
SURFICIAL AQUIFER PUMPING TEST SITE 2
SURFICIAL AQUIFER MONITORING WELL
CONTINUOUS WATER LEVEL RECORDING STATION
SURFACE WATER QUALITY SAMPLING STATION AND STAFF GAGE-STREAM GAGING STATION
SURFACE WATER QUALITY SAMPLING STATION AND CONTINUOUS STREAM WATER LEVEL RECORDER
GROUNDWATER STATIONS SAMPLED FOR RADIOACTIVITY
RAIN GAGE
MICROBAROGRAPH
MONTHLY WATER QUALITY SAMPLING STATION
N
0
2,000
4,000
SCALE IN FEET

FIGURE 7-13. WATER SAMPLING STATIONS.

SOURCE: FARMLAND INDUSTRIES, INC., DRI, JUNE 1979.

Samples were analyzed for the following physical and chemical parameters: temperature, pH, conductivity, suspended solids, turbidity, color, total organic carbon, dissolved oxygen, oil and grease, alkalinity, dissolved silica, fluoride, sulfate, fecal coliforms, and the nutrients, nitrogen (measured as nitrate/nitrite, ammonia, Kjeldahl, and total organic nitrogen) and phosphorus (measured as ortho- and total phosphate).

An additional effort involved the collection of samples in October 1979 and March 1980 by WCC (Table D-15) from points M-5, M-6, and M-7--where Oak, Hickory, and Troublesome Creeks, respectively, leave the Farmland property. The October 1979 sampling was done as part of a split-sample analysis with ESE and included a broad list of parameters (Table 7-8). The March 1980 analyses were for a reduced number of parameters with no split samples. All analyses of the WCC samples were by Wilson Laboratories of Salina, Kansas.

Existing Water Quality

Surface water quality on and adjacent to the Farmland project site has a tendency to vary with time, but is generally good. The primary causes of this observed variation appear to be related to several factors, of which stream discharge rates, biologic activity, and drainage basin land use seem to be the most important.

The ionic strength of the local surface waters is quite low (<5.0 mg/l). The dominant cations include calcium, magnesium, and sodium, while bicarbonate and chloride are the primary anions. The color of these waters is yellow-brown due to the leaching of organic material, and pH values tend to be slightly acidic. Based on their dissolved salt content, these surface waters can be characterized as being similar to the waters of the Surficial Aquifer, a result that is not entirely unexpected considering the role of this aquifer in providing baseflow to the surface streams.

While only limited flow data were taken during the water quality sampling effort, those which were taken indicate that water quality conditions are in part related to streamflow rates. Regression analyses of these data and the corresponding water quality data found that dissolved solids levels (as measured by conductivity) tended to be inversely related to flow rate. Representative correlation coefficients ranged from -0.2 in Oak Creek to -0.39 in Hickory Creek. This relationship indicates that the dilution accompanying storm events in the rainy season tends to lower the concentration of dissolved minerals. Suspended solids levels, on the other hand, tend to increase, especially immediately after rain events, as a result of rain-related erosion.

Other parameters exhibiting similar seasonal behavior include dissolved oxygen and nitrate/nitrite nitrogen, both of which had their lowest observed values during the rainy summer months. However, in this case the causative factor behind the observed drop in concentration is probably biologic rather than physical. Several biologic mechanisms might be responsible for the reduced oxygen levels. Likely candidates include the nitrification of ammonia, oxidation of organic materials, iron-organic matter interactions in colored waters, and plant respiration. Likewise, the high levels of plant photosynthetic activity during these months could result in a rapid uptake of nitrate from surface waters, thereby also depleting nitrate/nitrite levels.

In order to assess the potential quality differences between individual water bodies in the vicinity of the site, statistical analyses of the data presented in Appendix D were carried out for each stream. The results of these analyses are provided in Table 7-9. The results indicate that these water bodies can be divided into two groups: those which derive most of their drainage from the Farmland property (i.e., Hickory and Oak Creeks) and those which drain areas outside of the site (Peace River and Troublesome Creek). For example, dissolved oxygen, nitrate/nitrite nitrogen, phosphate, and fluoride all tend to be higher in these latter two streams. The difference in dissolved oxygen levels can probably be attributed to differences in the biologic communities in these waters. The first group of streams tends to be more intermittent in nature and has a lack of tree cover, which allows for higher water temperatures and the development of dense growths of rooted emergent and floating plants such as water hyacinths, pickerelweed, and smartweed. The presence of such dense vegetation can result in high oxidation and respiration rates, thereby depressing dissolved oxygen levels. The slightly higher levels of organic nitrogen and total organic carbon at these locations are also indicative of an oxidative environment.

The higher levels of nitrate/nitrite nitrogen found in the Peace River and Troublesome Creek, in conjunction with lowered ammonia levels, may be the result of nitrifying bacteria. These bacteria convert ammonia to nitrate by chemosynthesis. In general, the nutrient levels observed in all of the waters monitored are indicative of an aquatic system that has a high level of nutrient enrichment with nitrogen being the limiting nutrient.

Fluoride levels are also highest in the waters of the Peace River (mean value of 1.4 mg/l). The creeks are substantially lower at a mean value of 0.32 mg/l. The levels observed in the Peace River are probably the result of land use activities, such as existing mining operations, in the upper portions of the Peace River basin. Phosphate mining operations, for example, can increase fluoride levels by allowing the phosphate-bearing mineral, fluorapatite ($Ca_5(PO_4)_3F$) to dissolve in water. The dissolution of phosphate-bearing minerals, in addition to the upstream application of fertilizers and their subsequent runoff, are the probable sources of the higher phosphate values observed in the Peace River.

Compliance With Standards/Criteria

A key aspect in assessing the quality of these surface waters is their compliance with applicable State of Florida and Federal criteria. A compilation of the pertinent water quality standards and criteria is provided in Table 7-10. The criteria reviewed included the Florida Standard for Class III Waters (Recreational-Propagation, Management of Fish and Wildlife), the National Interim Primary Drinking Water Regulations, and the U.S. EPA Quality Criteria for Water (1976).

Of the above standards, the dissolved oxygen standard for Florida Class III waters was violated with the greatest regularity. However, the cause of this violation is a naturally occurring phenomenon, which results from the physiographic structure of these waters. Similarly, occasional violations of the alkalinity, pH, fluoride, iron, and fecal coliform standards/criteria have occurred. For the most part, these violations also appear to be a reflection of natural conditions in these waters. Since these waters are currently supporting moderately diverse faunal communities, it is therefore concluded that these particular violations do not warrant concern.

7.2 ENVIRONMENTAL CONSEQUENCES OF THE ALTERNATIVES

The proposed mining and processing of phosphate rock at the Farmland site and subsequent reclamation of disturbed land will result in adverse impacts on surface water quantity and quality at the site. This section contains a description of the surface water quantity and quality impacts associated with the alternative methods of accomplishing the identified project goals. The discussion is arranged by project component so that the alternative methods for any given component can be examined to an equal degree, thus providing a basis for the comparison of alternatives. The first alternative discussed under each component is Farmland's proposed action (Section 2.0). Only those project components having impacts relating to surface water quantity and quality are considered in this section. The last discussion within the section considers the impacts of the no action alternative as it applies to the project as a whole.

7.2.1 MINING

Dragline Mining (Farmland's Proposed Action)

Quantity. Land clearing in preparation for mining will increase surface water runoff from areas prior to mining, but because Farmland proposes to minimize the amount of cleared land (e.g., only about 20 acres at any given time) this impact should be minimal. The land acreage cleared during a given year will likely be at its highest just prior to the wet season, since the heavy machinery used in such clearing would be more difficult to operate on the saturated terrain. Rainfall from cleared land that has not been mined will continue to flow to natural streams. As mining advances a greater proportion of surface water would be retained in the active pits, with less flowing overland into existing creeks.

The most significant impact on surface water flows will result from the retention of water in the mine pits. Precipitation caught in the pits will become part of the water recirculation system. Thus, runoff from the site during mining will be less than prior to mining and stream flows (even flood flows) will be less (Table 7-11). It is estimated that by the fifteenth year of mine operation the total average stream flow from the Farmland site will have decreased by about 2 cfs (5 percent). Data are presented for year 15 because that is the year in which the largest total percentage of land is expected to be disturbed. The stream flows in Table 7-11 include the water expected to be discharged from the mine recirculation system into Hickory and Oak Creeks. These discharges are only expected to occur during periods of high rainfall and flows. If such discharges were not made, the maximum reduction in stream flow from the site during mining were be about 5 cfs (i.e., 3 cfs will be returned to the streams as mine water discharge--resulting in a stream flow reduction of about 2 cfs).

Farmland's proposed mine plan calls for the mining of portions of the Oak Creek and Hickory Creek 25-year floodplain. Diversion channels will be constructed prior to such mining so that the flows can be diverted to adjacent systems. Such diversions will be graded with the necessary meanders and vegetated prior to altering the flow patterns. These diversions will be designed for a 25-year rainfall event. Following mining, floodplains will be back-filled and graded to form a new stream channel and revegetated prior to the reintroduction of the stream. During the mining of Hickory Creek, flow will be diverted to Troublesome Creek. The flood flow in Troublesome Creek would be about 40 percent greater for a 25-year rainfall event and 44 percent greater for a 100-year flood if these events were to occur while Hickory Creek is diverted to it. The diversions are described in more detail in the following section.

Less dramatic than the effect of drainage basin changes, but still a factor in the overall impact of precipitation on the mine property, will be the effects of decreased infiltration rates. Infiltration will essentially not occur on the land areas (111 acres) covered by buildings, pavement and other impervious materials. Also, it is expected that the infiltration rate in the clay settling areas (1078 acres) and sand-clay mix areas (3915 acres) will be much less than the original rate. The result will be increasingly greater runoff as the reclamation proceeds. This tendency, however, will be more than offset by the presence of onsite retention areas, with the overall net impact being one of about a 0.5 cfs decrease in runoff.

Another factor likely to significantly affect local stream flows will be a reduction in baseflow which could occur when mine pits near a stream are dewatered. Baseflow in a portion of a stream could be locally absent or less than average during the time that an active mine pit abuts the stream. In dry years groundwater may contribute up to 40 percent of the annual runoff from these streams. In wet years at least 25 percent of the flow is from groundwater. Mining is planned within 200 feet of Troublesome Creek in years 10, 15, and 17; and within 100 feet of preserved portions of Hickory Creek in years 1, 12, 13, and 17; and within 100 feet of Oak Creek in years 1, 4, 6, and 10. It is estimated that 0.4 gal/min per foot of mine cut will enter the mine pits (assuming saturated conditions). Thus, a 3000 foot cut directly adjacent to Oak Creek in mining Block 10A would have a maximum flow of about 3 cfs or 3 percent of the creek's average flow. However, this impact would only be temporary.

A discussion of the water quantity impacts on specific surface waters is presented in the following paragraphs.

Troublesome Creek. There is no mining planned for the Troublesome Creek floodplain. The only mining to be done in this drainage basin will be between years 10 and 19. The largest impact to the Troublesome Creek system will likely be the increased flow during years 13 to 17 resulting from the diversion of Upper Hickory Creek. On the average this additional flow will be only about 4 cfs, but flood flows would result in a more significant addition. The added water would increase the level of the 100-year floodplain in Troublesome Creek by 1 foot. Although some of the area adjacent to the 100-year floodplain (as calculated without the diversion) is scheduled to be mined during the time of the diversion, the channel is fairly steep-walled and floodwater, even with the diverted flow, would not inundate the mining area.

Troublesome Creek flows into the Peace River on Farmland property. The increased flow in Troublesome Creek (from the Hickory Creek diversion) will be so small in comparison to the flow in Peace River that the diversion will have no detectable effect on the river. This flow would normally enter the river through Hickory Creek--about 1 mile downstream of Troublesome Creek.

Hickory Creek. The drainage basin of Hickory Creek contains the areas designated for: the central office for the mine, the beneficiation plant, the clear water pond, and parts of clay settling areas I and IIB. The western divide of Upper Hickory Creek basin is also to be realigned to the west of its original location. However, the net change in the area of the Hickory Creek drainage basin will be negligible and stream flow at the exit of Hickory Creek from the mine property will be about the same after mining as before.

Flows in Hickory Creek will be greatly altered during the mining of its stream channel. In order to permit mining of portions of the Hickory Creek floodplain, two stream diversions are planned for Hickory Creek. Only about half the length of its original floodplain on the Farmland property is to remain undisturbed. The biggest diversion will be that from Upper Hickory Creek to Troublesome Creek across Sections 1 and 2, T35S R24E. The diversion will be made just below a preserved section of the floodplain. The flow will be diverted for about 4 years while the original floodplain is mined and reclaimed with a lake system. This will deprive the floodplain of lower Hickory Creek of its usual supply of water (about 4 cfs at the point of diversion). Dewatering of the Surficial Aquifer when that area is mined (years 12-14) will further deprive the system of its water supply, to the point that Hickory Creek is likely to be dry at the property exit for a large part of the year (i.e., a temporary loss of 6.2 cfs average flow). The other diversion in the Hickory Creek basin will be to a tributary in Section 26, T34S R34E. This tributary will be permanently relocated from a mineable area to one that is to be otherwise undisturbed. The resultant differences in flow are expected to be slight.

Oak Creek. The portions of Oak Creek to be preserved include most of the Oak Creek Islands area and floodplain. However, parts of clay settling areas I and IIB and all of settling area IIA lie within this drainage basin. Settling area IIA lies just upstream of the Oak Creek Islands area. Two diversions are planned in this area so that the 10.6 cfs average flow can be maintained to Oak Creek Islands while settling area II is constructed and the area to its south is mined. Flow to the Islands area is currently ill-defined and variable. The proposed diversions will stabilize flow at the upstream end of the Islands area. The flow of Oak Creek should remain about what it currently is (15.8 cfs at the outflow from the property).

Quality. The primary surface water quality impact associated with mining would be the elevation of suspended sediment loads in the streams which flow from the site due to vegetation removal ahead of the mining operation. Farmland plans to limit the amount of cleared land ahead of the mining operation to only that actually necessary (usually about 20 acres at a given time). This should result in only minimal increases in suspended sediment levels in site streams.

A temporary increase in the suspended sediment load of Oak Creek will probably result from the planned dragline crossing of this creek in mine years 4, 6, and 10. However, this impact should be minimal if, as proposed by Farmland, such crossings are timed to coincide with dry, no flow periods and the crossing areas are vegetated prior to the crossing and returned to their original contours afterwards.

Spills of various materials might also affect water quality. The potential effects of spills of gasoline and diesel fuel are primarily controlled by evaporation losses. For spilled gasoline, almost total evaporation might be expected within several hours. Approximately one-half of a No. 2 fuel oil spill might evaporate in a similar amount of time, while lesser amounts would evaporate for a No. 4 fuel oil spill. The precise rate and total amount of evaporation is related to a number of variables including air and water temperature, humidity, wind, and condition of the spilled material. Typically, the bulk of oil components subject to evaporation will be lost in the first 24 hours of the spill.

Dredge Mining

Quantity. Dredge mining would require that sufficient water levels be maintained in the active mining area to support the dredge unit. The water contained within the active mining area would likely be turbid and contain higher concentrations of some parameters than water in the adjacent undisturbed Surficial Aquifer.

Quality. At times when the level of the Surficial Aquifer is below the water level in the active mining area, some of this water could move laterally and degrade its quality.

Bucketwheel Mining

Quantity. Bucketwheel mining would have impacts on surface water quantity similar to those discussed under dragline mining.

Quality. Bucketwheel mining would have impacts on surface water quality similar to those discussed under dragline mining.

7.2.2 MATRIX TRANSPORT

Slurry Matrix Transport (Farmland's Proposed Action)

Quantity. A break in a matrix slurry pipeline near a stream could cause downstream flooding. The water flow through the slurry pipeline will be equivalent to about 35 cfs, well above the average flow of any stream on the site.

Quality. A break in a slurry pipeline near a stream crossing could result in a dramatic increase in suspended solids content and smaller increases in pH, fluorides, Ra-226, specific conductance, and total dissolved solids levels in the affected stream. However, the potential for such an occurrence should be minimal if, as proposed by Farmland, double walled pipelines equipped with cut-off valves and pressure sensitive alarms are used at stream crossings.

Conveyor Matrix Transport

Quantity. This alternative offers a potential water quantity improvement because of the reduction in spill potential described above for matrix slurry transport.

Quality. This alternative offers a potential water quality improvement because of the reduction in spill potential through the elimination of slurry pipelines. As indicated above, spills of matrix material from slurry pipelines would increase levels of conductivity, radium-226, suspended solids, and total dissolved solids. Much smaller increases might occur if matrix is lost from a conveyor transport system.

7.2.3 MATRIX PROCESSING

Conventional Matrix Processing (Farmland's Proposed Action)

Quantity. Conventional matrix processing involves the separation of the matrix fractions by washing and flotation methods. The waste streams from the plant consist primarily of sand and clay in slurry form. Some of the water used in these slurry lines create a potential for downstream flooding, the extent of which would depend on the volume being pumped and the duration of the break. Since such a break would have the greatest affect at a stream crossing, Farmland plans to use double-walled pipe culverts at all stream crossings and install pressure sensitive devices that will sound an alarm should a failure in the inner pipe occur.

Quality. In the event of a break in any of the waste or water return pipelines, a potential for degradation of surface water quality would exist. The degradation would be greatest if a clay slurry pipeline broke near a stream crossing. Such a break would greatly increase suspended solids levels in the receiving stream. The use of Farmland's preventive measures described above should minimize the potential for such degradation to occur.

Dry Matrix Processing

Quantity. Dry matrix processing would likely eliminate the potential for the water quantity impacts disucssed above. If the dry processing technique involved only dry separation (i.e., waste sand and clay would be rewetted and pumped to the disposal site following separation), the impacts would be the same as described above for conventional matrix processing.

Quality. Dry matrix processing would also likely eliminate the potential for water quality impacts associated with handling of the sand and clay wastes generated.

7.2.4 WASTE SAND AND CLAY DISPOSAL

Sand-Clay Mixing (Farmland's Proposed Action)

Quantity. Farmland proposes to use sand-clay mixing within mined areas as their primary waste disposal technique. Use of this technique over 3915 acres of the site, as planned by Farmland, will result in the creation of a land surface which will maintain surface water flow from the site at about the existing rate (see 7.2.7 RECLAMATION). The 1078 acres of clay settling ponds which will also be created will remove this acreage from the surface water drainage basins for the operational life of the mine (see 7.2.7 RECLAMATION).

Quality. Sand-clay mixing should result in more rapid dewatering of the sand and clay slurry input to the mix area, but the actual amount cannot be determined until more experience has been gained in the use of this technique. This may result in excess water in the recirculating water system (requiring a discharge to surface waters) prior to the point at which such a discharge would have been required if conventional sand and clay disposal methods were used (see next section). The impacts of discharges of effluent to surface waters are discussed under "Water Management Plan" alternatives.

Farmland also proposes to dispose of waste sand and clay in separate impoundments. Waste clays will cover 1078 acres of the site; sand tailings, 104 acres. The clay impoundments will receive a clay slurry at about 3 percent solids which eventually settle to about 25-30 percent solids. During the time when an area is receiving clay slurry, the impoundment would contain material at a wide range of densities--from near 30 percent to less than 3 percent solids. Failures in the dikes used to impound these wastes have occurred in past years, but since the implementation of the state construction and inspection standards in 1971, no dam built by the phosphate industry has failed. Strict compliance with the current standards should insure the integrity of all dams proposed by Farmland. However, an estimate of the maximum area which would be affected by a dam break has been made (Farmland 1979a). The worst-case situation would involve a break in Settling Area I, the largest (495 acres) undivided settling area proposed for the operation. In estimating the area affected by a break in the retention dam for this area, the following assumptions were made:

- the area is filled to its maximum operating capacity of 35 feet above natural grade;
- the break occurs in the north side of the dam and clays escape onto level terrain; and
- the clays are in a semi-solid state and form a slope of 1:1000 away from the breach in the dam.

Based on these assumptions, approximately two-thirds (or 11,500 acre-feet) of the impounded clays would escape and cover an area of approximately 6 square miles. The assumption of level topography is, of course, not strictly realistic. Because of the entrenched topography of the onsite drainage courses, most of the clays released from a dam break would probably find their way into Oak or Hickory Creek. Probably only a few hundred acres of land would be affected, and the clay spill would affect primarily the onsite and downstream stream courses.

In comparison to the worst-case situation of a break in one of the clay settling areas, the area affected by a break in the thickener berm or a sand-clay retention dam would be much less. Only about 15 acre-feet of clay suspension will be impounded above natural grade in the thickener; therefore, even if all the above grade impounded clays escaped, the released material would be only 0.13 percent of the material released in the worst-case situation. Because of the rapid consolidation of wastes projected for sand-clay landfills, most of the wastes confined in these areas will not be in a fluid state. The area affected by a break in a sand-clay retention dam should, therefore, be relatively small (Farmland 1979a).

Conventional Sand and Clay Disposal

Quantity. The disposal of all sand and clay wastes generated by the mine using conventional (separate) methods would result in the entrainment of a larger amount of water than would sand-clay mixing. This would result in a reduction in the potential need to discharge from the recirculating water system. The large open ponds which are characteristic of conventional clay disposal would also provide greater surface area for evaporative water losses, further reducing the potential need for a discharge, and would offer water storage capacity not provided by the smaller dikes of sand-clay mix areas.

Quality. If conventional sand and clay disposal techniques were used by Farmland, water retention on the site (i.e., zero discharge of effluent) might be accomplished more effectively. On the other hand, the creation of larger areas containing impounded clays would increase the probability of an accidental release which would have serious effects on water quality. If Farmland were to dispose of all the waste clays in such settling areas, approximately 57 percent (2700 acres) of the mined-out area would contain impounded clays to a height of 35 feet above natural grade. Since these areas would be compartmentized, a break would not result in the release of such clays from the entire area. Therefore, the impact should be comparable to that described for a break in a dike of Farmland's proposed Area I. However, the probability of such a break will be greater.

7.2.5 PROCESS WATER SOURCES

Groundwater Withdrawal (Farmland's Proposed Action)

Quantity. The withdrawal of groundwater from deep (1400 feet) wells should not have any significant affects on surface water quantity in the vicinity of the site.

Quality. The withdrawal of groundwater from deep (1400 feet) wells should not have any significant affects on surface water quality in the vicinity of the site.

Surface Water Impoundment

Quantity. Surface waters impounded on the site for use as process water would consist largely of stored flood flows. The dams used for such storage would probably best operate with the normal level at elevation 65 feet, allowing the 5 feet up to the 70 feet as emergency capacity to catch any heavy rainfall periods. This 5 foot capacity would be approximately 5300 acre feet of water. The water available to be collected in any major reservoir system depends upon available rainfall. Farmland already plans to collect a nominal average of 10.6 cfs of normal rainfall, and 18.6 cfs of the 25 year maximum flood flow. The excess flow available from the site land area could be expected to be as much as 6.6 cfs (normal rainfall) and 12.6 cfs (for a 25 year maximum flood). Allowing for the minimum discharge of 2.6 and 3.7 cfs to Oak and Hickory Creeks, respectively, the potential reservoir gain, depending upon rainfall intensity, would be:

	2 Yr	5 Yr	25 Yr	100 Yr
Hickory Creek (Acre feet)--	61	489	1435	2347
Oak Creek (Acre feet)--	472	1045	2131	3445

These quantities allow for continuous normal stream flow as well as a certain amount trapped by Farmland within its system. Converting the above flows to million gallons per day (mgd) on a 365 day year, the source volume would be:

	2 Yr	5 Yr	25 Yr	100 Yr
Hickory Creek (Acre feet)--	0.05	0.44	1.28	2.10
Oak Creek (Acre feet)--	0.42	0.93	1.90	3.08
	0.47	1.37	3.18	5.18

Such storage would prevent flood flows from reaching the downstream portions of the affected streams.

Quality. A benefit of this alternative would be its potential to store excess clarified water from the recirculating water system, reducing the need for a direct discharge to Oak Creek or Hickory Creek. However, because of the relatively high nitrogen and phosphorus content of Hickory and Oak Creeks (which would feed the reservoirs), the long retention time of water in the reservoirs, and the fairly shallow depth of the reservoirs, high algal productivity may result. Potential water quality problems within an impoundment resulting from such high plant productivity may include algal mats and odors.

7.2.6 WATER MANAGEMENT PLAN

Discharge to Surface Waters (Farmland's Proposed Action)

Quantity. Farmland proposes to utilize a water management plan which incorporates recirculation and reuse to a large degree. Normally, there will be no discharges from the mine recirculating water system because retention areas will have sufficient surge holding capacity to accommodate normal process flow and rainfall variations. Water will be discharged to Hickory Creek only during periods of heavy rainfall (Farmland 1979a). The additional volume of water input to natural flows at those times should not cause any significant flooding, etc. above that which would normally occur downstream of the discharge point during such periods.

Quality. As indicated above, no discharge of effluent is anticipated under normal rainfall conditions. However, under extreme rainfall conditions excess water will be discharged into Hickory Creek from the clear water pool, but only after flowing through the clay settling area. Beneficiation plant effluent, including reagents used in the flotation treatment, will be mixed with waste clays as these are slurried. The reagents used and the ratio of dilution in the wastewater if they were to pass through the beneficiation process without chemically reacting would be as follows:

Reagent	Consumption (gal/day)	Ratio of Dilution
Sodium Hydroxide	5508	9,600:1
Fatty Acid	3917	13,500:1
Fuel Oil	5998	8,800:1
Sulfuric Acid	3794	13,900:1
Amine	6242	8,500:1
Kerosene	612	86,400:1

Most of the reagents should adsorb onto the clay particles and settle in the disposal areas, leaving only trace amounts in the water.

Depending on flow in Hickory and/or Oak Creek, these discharges may have some effect on water quality in these creeks. Table 7-12 presents a comparison of the water quality characteristics of slime supernatant from 15 beneficiation plants in Florida with surface water characteristics at the Farmland site. If discharges occur as planned (i.e., primarily in response to heavy rainfall events) increases in the concentrations of selected water quality parameters might be expected. A comparison of the data in Table 7-12 indicates that increases in the receiving water concentrations of specific conductance, fluoride and sulfate would occur. During the high flow season, it is not expected that these increases would exceed water quality standards (Table 7-10). If these discharges occurred during the dry season, when no flow conditions are common, the Florida fluoride standard might be exceeded. Based on the Table 7-12 data, no other water quality standards are expected to be exceeded due to the effluent discharge. A more recent categorization of effluent from similar phosphate rock processing plants by Ochsner and Blackwood (1978) (Table 7-13) leads to the same conclusion.

Another constituent of concern is Ra-226. Mills, et al. (1977) reviewed the beneficiation process with respect to radioactivity in water. If the findings of that study are adjusted using the ratio of central Florida matrix radioactivity to that of the Farmland site, the following can be concluded:

- Most of the waste product radioactivity will be present in the clay entrained water. For the Farmland site, this amounts to approximately 3600 gpm of water at a radium-226 concentration of <2 pCi/l (dissolved) and 50 pCi/l (undissolved), the latter value being highly dependent upon the total suspended solids in the clay wastes.

- Although no chemical processes are used to treat the discharge from clay settling areas, the concentration of radium-226 will normally be <1 pCi/l due to removal of suspended solids by settling and the incorporation of some dissolved material in the settling floc.

The concentrations of Ra-226 in dissolved and undissolved fractions of effluent from several clay impoundment effluents (EPA 1979b) have been found to be generally about 0.7 pCi/l (dissolved) and 0.6 pCi/l (undissolved). Comparing these data with available data on surface water Ra-226 concentrations in affected streams (Table 7-12) indicates that Ra-226 concentrations will be higher than the receiving waters. However, existing stream RA-226 levels may not be exceeded if plant discharges occur as expected during periods of high creek flows. In addition to Ra-226, Ra-228 levels will increase at discharge points. Recent evidence (Michel and Moore 1980) indicates that the Ra-228/Ra-226 ratio may be above 2, which would mean that the 5.0 pCi/l combined Ra-228 and Ra-226 water quality standard might be exceeded at the discharge point on occasion. The EPA effluent guideline for the phosphate industry is 9 pCi/l of Ra-226.

Connector Wells

Quantity. Use of connector wells to discharge excess noncontaminated water from the recirculating water system to deep aquifers would reduce the potential for a surface water discharge and the incremental increase in stream flow that such a discharge would produce.

Quality. Use of connector wells would reduce the amount of water collected in the recirculating system and consequently the amount of effluent which would be discharged to surface waters. Disposal of collected water in deep aquifers would likely improve water quality in terms of total dissolved solids, but would probably degrade groundwater quality constituents such as fluoride, phosphate, and nitrate.

7.2.7 RECLAMATION

Farmland's Proposed Reclamation Plan

Quantity. As described under Farmland's proposed waste sand and clay disposal plan, most (80 percent) of the reclaimed mine site will be filled with a sand-clay mixture. A single clay impoundment covering 583 acres will also remain, and 235 acres of lakes will be formed. Farmland proposes to deposit sand-clay mix and grade overburden piles such that surface water will flow from these areas to natural stream courses (Figure 7-14). The post-reclamation drainage pattern planned for the site is shown in Figure 7-14.

The reclaimed surface soils will probably have infiltration rates lower than the original soils, thus surface runoff will probably be greater. However, additional retention and evaporation will occur from the lakes and marshes created as part of the reclamation plan. Taking these losses into account, an annual average decrease in surface water flow on the order of 0.5 cfs is predicted for the entire site (Table 7-11).

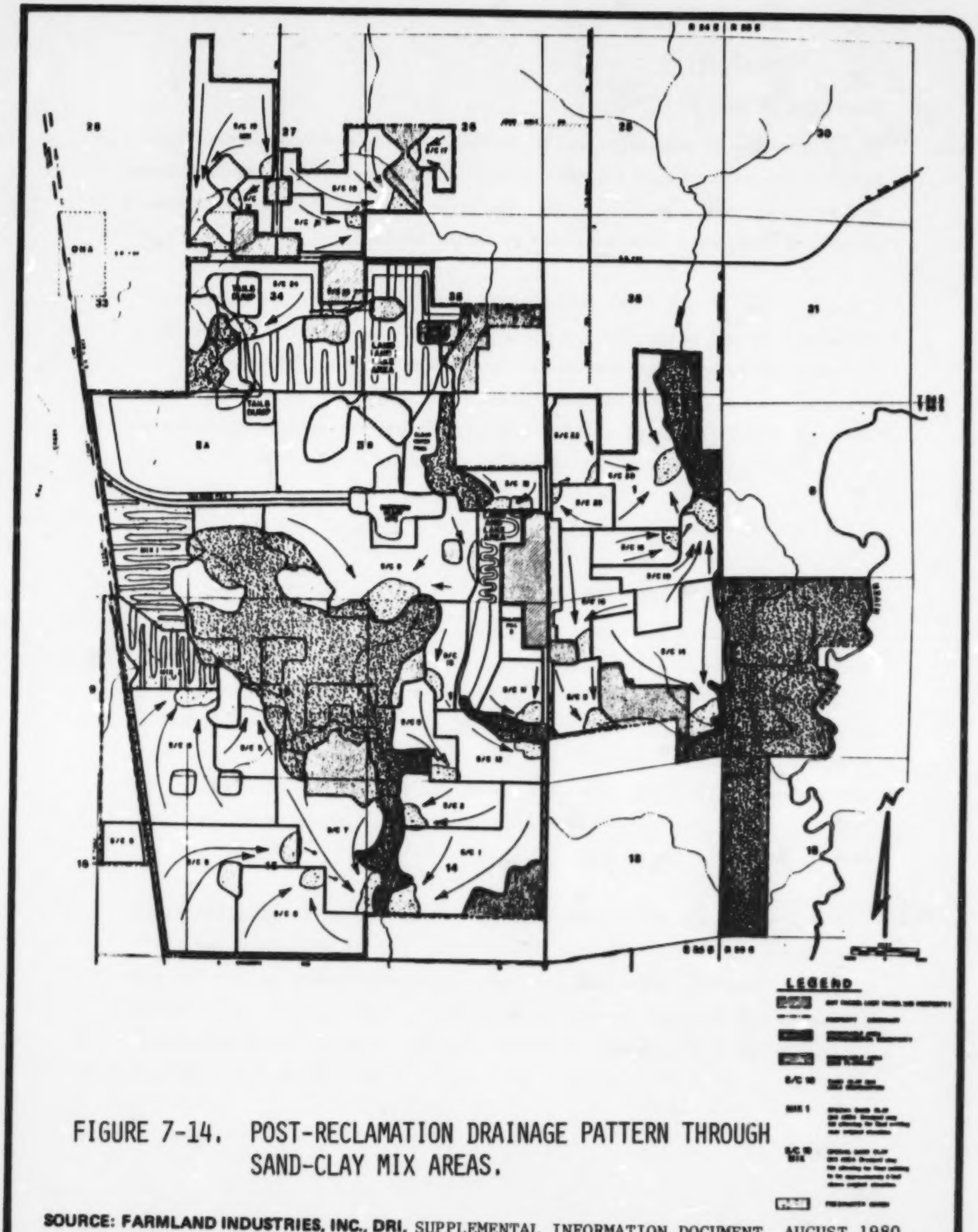

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FIGURE 7-14. POST-RECLAMATION DRAINAGE PATTERN THROUGH SAND-CLAY MIX AREAS.

SOURCE: FARMLAND INDUSTRIES, INC., DRI, SUPPLEMENTAL INFORMATION DOCUMENT, AUGUST 1980

Quality. The land cover established on the reclaimed site will be substantially different from that now present. Improved pasture/agricultural land will increase from 2416 acres at present to 4097 acres following reclamation. Although the pasture areas will be planted with forage crops, it is expected that the runoff from these areas will have higher levels of suspended particulates and other parameters than at present. The application of other materials (e.g., fertilizer) to these lands would also result in increases in the concentrations of these materials in runoff reaching streams leaving the site. If the pasture areas support larger numbers of livestock than are currently present, levels of additional parameters (e.g., coliforms) could also be raised.

Conventional Reclamation

Quantity. Reclamation as conventionally practiced in the Florida phosphate industry would result in the creation of about 2700 acres of plateau-like terrain (clay impoundments) at an elevation of 35 feet above natural grade. Reestablishment of surface water flows from these areas would not be as easily achieved as will be the case for Farmland's proposed action. During the years that the dikes for such impoundments were standing, rainfall would be entrapped with the dewatering clays--virtually eliminating surface flows from these areas.

More extensive lake areas would also be likely using conventional reclamation methods. These lake areas would further reduce surface flows through retention and evaporation.

Quality. Conventional reclamation would produce a land surface which, to a large extent, would be limited to use as pasture. Although some differences may occur, surface water quality impacts would likely be similar to those described for Farmland's proposed reclamation plan.

Natural Mine Cut Reclamation

Quantity. Natural mine cut reclamation would produce an uneven land surface with drainage from the site hampered by numerous windrows and impounded water areas.

Quality. Natural mine cut reclamation would produce a land surface not suitable for use as agricultural land, therefore the potential surface water quality impacts resulting from such use would not occur. The steep slopes of the windrows would tend to erode, creating high suspended sediment levels in the impounded water areas; however, as natural revegetation progressed, these levels would diminish. Over time, surface water quality would probably improve to at least existing levels.

7.2.8 THE NO ACTION ALTERNATIVE

Quantity. Under the no action alternative no appreciable changes in the existing surface water quantity are anticipated. The present seasonal changes in streamflow will not be affected, flood flows will not be changed, nor will the extent of flooding. This alternative will also cause no change in the hydrologic characteristics of streams or change in rate of baseflow to them.

Quality. Surface water quality under the no action alternative will depend on the future uses for land in the area. If land use patterns in the immediate area remain fairly constant over the next few decades, surface water quality should remain much as it is today. If other phosphate mining and processing projects are permitted, selected stream waters may show increases in TDS, sulfate, phosphate, nitrogen, and fluorides. The amount of increase would depend upon the type of mining and chemical processing operations utilized in these facilities. Slight increases in radiological concentrations in surface waters may also be expected.

7.3 REFERENCES

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Table 7-1. MONTHLY RAINFALL (inches).

	1941 - 1970 Regional Average[a] South Central District Florida	June 1977-Aug. 1978 Averages[b] for On Site Stations		
		RG1*	RG2*	RG3*
January	2.27	2.74	3.01	2.37
February	2.76	3.23	3.07	2.85
March	3.67	2.63	2.53	2.62
April	2.68	0.15	0.14	0.70
May	3.43	3.45	4.56	5.18
June	7.31	16.25	11.59	7.62
July	8.00	6.77	8.60	8.17
August	7.71	6.39	5.93	5.34
September	7.50	7.41	6.87	6.57
October	4.02	3.53	2.32	2.65
November	1.87	2.36	2.75	2.35
December	1.99	2.16	3.03	2.20
Annually	53.18	57.07	54.40	48.62

* Station locations shown on Figure 7-1.

Sources: a. R.B. Thompson, Floria Statistical Abstract, 1976.
b. P.E. LaMoreaux, Hydrologic Monitoring Program, Aug. 1978.

Table 7-2. PRE-MINING DRAINAGE PARAMETERS.

	Total Drainage Area (acres)	Drainage Area to Exit (acres)	Drainage Area on Site (acres)	Average Annual Flow (cfs)	Required Annual Runoff (inches)
Troublesome Creek	11,925	11,328	1,167	17.5	13.42
Hickory Creek	4,180	4,170	2,261	6.9	15.30
Oak Creek	19,014	15,012	4,055	15.8	9.14
Peace River	1,120,000	556,800+	250	73.0+	11.39
TOTAL	1,155,119	30,510*	7,733	40.2*	11.57†

*Excludes that of the Peace River.
†Weighted average runoff for the drainage area of the three creeks above their exits from the Farmland property.

Sources: P.E. LaMoreaux, Hydrology Monitoring Program, Aug. 1978.
Zellars-Williams, Inc., Mine and Waste Disposal Plan, July 1978.

Table 7-3. AVERAGE FLOW OF STREAMS AT SELECTED SITES ON PROPERTY.

Surface Water Site No.	River Mile	Cross Section No.	Location	Drainage Area (Sq.Mi.)	Average Flow (cfs)
Troublesome Creek					
SW 11*	2.40	T-7	Inflow to property	16.6	16.4
SW 12	1.50	T-1	Outflow from property	17.7	17.5
Hickory Creek					
SW 4	5.23	H-19	Outflow upper segment	2.56	2.6
SW 9*	4.39	H-16	Inflow to property	3.64	3.7
SW 10	1.75	H-4	NW 1/4 SE 1/4 Sec. 11, T35S, R24E	5.63	6.2
SW 13*	.67	H-0.5	Outflow from property	6.12	6.9
Oak Creek					
-	7.48	O-16F	SE 1/4 SE 1/4 Sec. 33, T35S, R24E	0.9	0.9
SW 2*	6.77	O-18	Inflow from upper Oak Creek below railroad	10.6	10.2**
SW 6	4.88	O-12	NW 1/4 SW 1/4 Sec. 11, T35S, R24E	15.5	14.9**
SW 8*	3.88	O-7	Outflow from property	16.4	15.8**
Peace River					
-	69.0	-	U.S.G.S. No. 02295637 at Zolfo Springs	826	697
SW 15	59.7	-	Property inflow	838 +	710 +
SW 16	58.3	-	Property outflow	870 +	730 +

* Index gaging stations with recorders.

** Based on total drainage with no adjustment for natural flood diversions to Brushy and Horse Creek.

+ Estimated.

Site locations are shown on figure 6-3.

Source: P.E. LaMoreaux, Supporting Report for Consumptive Use Permit, April 1979.

Table 7-4. FLOOD DISCHARGES ON FARMLAND INDUSTRIES, INC. PROPERTY.

RM	Cross Section	Monitoring Site		Discharge in Cubic Feet Per Second 2 Yr.	5 Yr.	25 Yr.	100 Yr.
Troublesome Creek							
2.40	T-7	SW-1	Inflow	365	776	1680	2900
1.50	T-1	SW-12	Outflow	381	811	1750	3020
Hickory Creek							
5.84	H-21		Inflow	100	213	459	791
5.23	H-19*	SW-4	Outflow	103	192	393	590
4.61	H-17		S.R. 64	134	257	535	832
4.39	H-16	SW-9	Inflow	157	306	641	1012
3.12	H-12	Sec. 2	Outflow	200	399	841	1350
2.28	H-7	Sec.11	Inflow	216	432	909	1480
1.52	H-3			232	466	989	1600
0.95	H-1			249	503	1070	1740
Oak Creek Islands							
7.48	O-16F	SW-1/4	SW corner Sec. 33	41	87	187	323
6.09	O-16A	S-1/8	Sec. 3	68	145	314	541
5.21	O-13**	SE 1/4	Sec. 10	307	546	984	1560
3.88	O-7**	SW-8	Outflow	351	640	1188	1910
Upper Oak Creek							
6.77	O-18	SW-2	Below RR	185	287	424	592

* Discharge below included the effect of a distributary to upper Oak Creek at RM 5.70 at the northern end of the site.

** Discharge included inflow from upper Oak Creek on Mississippi Chemical Corporation property.

A map showing the locations of monitoring sites, is given on Figure 6-3.

RM - River Mile

Source: P.E. LaMoreaux, Supporting Report for Consumptive Use Permit, April 1979.

Table 7-5. CHARACTERISTIC WATER QUALITY FOR THE PEACE RIVER BASIN, JANUARY 1970 - DECEMBER 1976.

Designation on Map[1]		Alkalinity (mg/ℓ CaCO$_3$)	BOD$_5$ (mg/ℓ)	Color (Pt. Co unit)	Conductivity (mho/cm)	Dissolved Oxygen (mg/ℓ)	Fluoride (mg/ℓ)	Nitrate-N (mg/ℓ)	Ammonia-N (mg/ℓ)	Organic-N (mg/ℓ)	pH (pH unit)	Ortho Phosphate (mg/ℓ)	Total Phosphate (mg/ℓ)	Temperature (°C)	Turbidity (JTU)	TOC (mg/ℓ)	Hardness (mg/ℓ)	Total Coliform[2] (No./100 mℓ)
P.1	Max	202	4.0	140	487	15.0	14.0	5.70	1.90	4.02	9.2	-	-	30.0	32.0	57.0	-	94
	Min	54	0.5	30	230	0.6	0.3	0.00	0.01	0.04	6.5	-	-	10.0	1.0	5.5	-	2
	Avg	105	2.0	63	352	6.2	3.6	0.20	0.17	0.62	7.7	-	-	24.7	6.7	26.3*	-	19*
P.2	Max	182	7.7	40	439	10.8	3.4	0.57	0.43	1.76	8.1	-	-	31.0	25.0	34.0	90	-
	Min	16	1.7	40	80	0.6	0.0	0.00	0.01	0.13	6.5	-	-	12.3	15.0	4.0	90	-
	Avg	106	4.0*	40#	273	4.7	0.6	0.14	0.15	1.33	7.4	-	-	24.1	20.0#	24.8#	90#	-
P.3	Max	168	8.1	200	790	10.9	5.2	2.10	0.93	13.00	7.8	-	52.00	35.0	150.0	47.0	230	-
	Min	13	1.2	3	210	1.7	0.9	0.00	0.01	0.29	4.8	-	0.04	10.0	1.0	8.0	61	-
	Avg	81	3.4	64	439	4.8	2.6	0.33	0.18	1.88	6.9	-[3]	10.41	23.8	19.1	21.3	130	-
P.4	Max	226	8.4	20	600	10.7	7.0	2.00	4.55	8.96	8.7	-	-	31.0	215.0	28.0	200	5,000
	Min	20	0.4	20	230	1.0	0.6	0.00	0.01	0.41	5.6	-	-	14.0	2.9	5.0	200	400
	Avg	104	3.2	20#	426	5.9	2.3	0.75	0.43	1.39	7.4	-	-	24.0	59.8#	13.8*	200#	2,700#
P.5	Max	216	9.5	-	-	8.1	15.5	9.40	29.40	1.72	8.5	-	-	31.0	86.0	-	-	-
	Min	20	0.7	-	-	4.0	0.6	0.00	0.00	0.08	6.1	-	-	12.8	6.5	-	-	-
	Avg	85	5.4*	-	-	5.5*	3.9	0.89	1.47	0.88	7.2	-	-	24.3	40.2#	-	-	-
P.6	Max	158	3.6	-	-	9.0	1.6	2.20	0.14	0.77	8.0	-	-	28.0	1.8	-	-	-
	Min	10	1.1	-	-	5.8	0.3	0.00	0.01	0.45	5.8	-	-	10.0	1.8	-	-	-
	Avg	64	2.0#	-	-	7.7#	1.0	0.50	0.05	0.60	7.1	-	-	21.8	1.8#	-	-	-
P.7	Max	178	78.0	252	530	10.3	18.0	4.30	3.80	7.95	8.7	5.56	-	30.0	20.0	28.0	-	5,100
	Min	8	0.0	0	3	0.4	0.2	0.00	0.00	0.48	4.0	4.81	-	11.1	2.1	3.0	-	100
	Avg	88	15.6	91*	219*	5.1	2.1	1.23	0.44	1.18	7.3	5.19#	-	23.2	6.2	12.3*	-	1,219*
P.8	Max	212	2.5	-	-	8.9	1.7	3.65	0.28	1.27	7.9	-	-	28.0	-	-	-	-
	Min	18	1.6	-	-	5.6	0.7	0.00	0.01	0.29	6.7	-	-	11.7	-	-	-	-
	Avg	68	2.1#	-	-	7.1#	1.2	1.25	0.13	0.83	7.3	-	-	23.1	-	-	-	-
P.9	Max	600	6.3	140	742	9.2	8.6	4.60	2.36	1.90	8.4	4.86	21.00	38.0	241.0	17.0	260	9,000
	Min	44	0.1	0	130	0.0	0.5	0.00	0.00	0.38	4.2	4.86	1.90	11.1	2.0	6.9	99	250
	Avg	76	2.0	55	413	6.3	1.4	1.23	0.22	0.91	7.3	4.86#	4.09	23.0	160.8	12.0#	166	2,735#
P.10	Max	61	1.7	200	300	9.6	0.6	-	-	0.59	8.0	-	-	31.0	6.0	35.0	77	-
	Min	16	0.7	10	93	4.5	0.3	-	-	0.55	6.7	-	-	13.0	5.0	0.0	38	-
	Avg	42#	1.2#	83#	180	7.1	0.5#	-	-	0.57#	7.3#	-	-	25.2	5.5#	17.1#	61#	-
P.11	Max	176	3.7	280	630	11.8	2.7	3.90	0.42	2.12	-	1.00	10.00	31.5	99.0	20.0	250	7,000
	Min	15	0.1	0	100	2.3	0.5	0.00	0.00	0.27	-	1.00	0.03	10.0	0.0	4.0	38	2
	Avg	54	1.7	86	358	7.4	1.4	1.13	0.11	0.92	-	1.00#	2.77	22.2	5.4	10.1	139	667*
P.12	Max	73	3.1	220	605	9.5	2.4	2.02	0.37	2.56	8.1	-	-	29.0	56.0	-	-	910
	Min	38	0.1	30	300	4.8	0.4	0.00	0.02	0.52	7.0	-	-	10.0	2.0	-	-	330
	Avg	49#	1.4	104#	446#	6.4	1.2#	1.00	0.16	1.33#	7.4#	-	-	23.4	9.2#	-	-	633#
P.13	Max	46	4.8	240	990	-	0.1	0.00	0.01	1.50	4.3	0.02	0.18	30.0	8.0	20.5	94	-
	Min	0	4.8	240	151	-	0.1	0.00	0.01	0.92	4.3	0.02	0.04	2.4	8.0	20.5	9	-
	Avg	30#	4.8#	240#	491	-	0.1#	0.00#	0.01#	1.21#	4.3#	0.02#	0.11#	23.5	8.0#	20.5#	64#	-
P.14	Max	74	2.5	300	750	9.0	1.4	2.00	0.45	2.50	8.2	-	-	29.0	19.0	-	-	580
	Min	38	0.3	30	260	4.0	0.5	0.00	0.04	0.54	6.4	-	-	10.0	1.0	-	-	110
	Avg	51#	1.2	130	540#	6.2	0.9#	0.64	0.16	1.35	7.4#	-	-	23.4	4.6#	-	-	355

[1] See Figure 7-11.

[2] Membrane Filter or Most Probably Number.

[3] To present as much information as possible from STORET data during January 1970-December 1976 and still keep the data validity in consideration, certain qualifier signals are included along with actual data values in the "average" column:

Absence of qualifier signal = The average presented is of at least 10 observations spanning a period of at least 3 years during January 1970-December 1976.
* = Average of at least 10 observation not spanning a period of 3 years for each of at least 3 years during January 1970-December 1976.
+ = Average of less than 10 observations spanning a 3-year period.
# = Average of less than 10 observations spanning a period of less than 3 years.
- = No data available.

Source: EPA (1978a).

Table 7-6. WATER QUALITY OF THE PEACE RIVER DURING PERIODS OF HIGH AND LOW DISCHARGE.

Basins	Sta.	Date (1965)	Discharge (cfs)		SiO_2	Fe	Al	Ca	Mg	Na	K	HCO_3	SO_4	Cl	F	NO_3	PO_4	TDS	Hardness as $CaCO_3$ Ca-Mg	NC	Sp Cond @25 C	pH	Color	Temp
Peace	9**	6/01		0	14	0.02	-	38	19	27	1.4	100	116	7.0	3.1	0.1	8.0	283	173	91	470	7.3	5	85
		9/14	M	188	14	0.04	-	22	6.4	20	2.7	68	37	21	1.1	1.5	2.7	161	82	26	242	7.0	80	83
	10	6/01	I	9.4	18	0.09	-	58	19	23	0.6	94	122	34	2.9	1.1	16	340	224	147	525	7.7	10	91
		9/13	I	19	19	0.00	2.6	3.5	1.3	258	5.0	227‡	280	32	11	0.6	18	664	14	0	1,400	9.9	20	80
	11	6/01	M	23	12	0.05	-	46	15	34	1.0	91	119	32	2.6	0.0	6.8	313	177	102	515	7.5	10	86
		9/14	M	218	17	0.04	-	31	8.2	21	2.6	50	64	23	2.1	3.2	16	213	111	70	320	6.8	80	82
	12	6/01	I	8.5	13	0.01	-	43	20	54	0.4	154	144	15	3.2	0.4	1.8	371	190	64	635	7.8	5	87
		9/14	I	32	5.5	0.01	0.5	39	12	30	0.3	92	105	11	2.6	0.4	4.5	255	147	72	480	7.2	20	85
	13	6/01		-	18	0.07	-	43	15	15	1.0	138	70	10	1.1	1.2	2.0	244	169	56	405	7.5	10	-
		9/14		-	14	0.09	-	27	9.8	19	2.4	63	51	18	1.4	5.7	6.4	186	108	56	280	6.9	80	83
	14	9/14	M	6.4	6.3	0.22	-	3.0	2.8	6.4	0.8	6	4.0	12	0.2	3.3	.7	43	19	14	79	5.7	160	78
	15	6/02	I	0.8	15	0.00	-	42	15	5.8	0.5	120	64	5.5	3.8	0.1	1.7	212	168	70	340	7.9	5	108
		9/14	I	0.7	20	0.00	-	62	16	6.8	0.8	140	83	8.0	3.1	0.1	13	282	220	106	455	7.5	5	87
	16	6/02	I	3.2	33	0.08	-	30	81	44	0.8	0	392	15	7.3	1.1	156	760	408	408	815	6.3	15	82
		9/14	I	5.2	33	0.18	3.1	64	18	34	1.0	0	210	12	7.0	0.2	131	511	234	234	620	4.6	70	87
	17	6/02	I	24	18	0.01	-	50	30	24	0.4	81	184	16	2.6	0.4	33	398	248	182	576	7.7	15	76
		9/14	I	69	18	0.05	0.6	40	13	16	1.2	28	106	13	4.2	0.1	36	311	154	154	390	7.0	40	-
	18	6/01	M	5.2	2.5	0.19	-	16	7.5	11	0.1	42	34	12	0.8	5.2	2.0	112	71	36	210	7.4	20	78
		9/14	M	52	7.8	0.32	-	13	4.9	8.0	0.8	25	24	14	0.9	1.4	3.7	91	52	32	152	6.7	110	78
	19	6/01	M	59	12	0.05	-	49	17	26	1.2	101	119	16	2.0	1.0	9.7	302	192	109	515	7.6	10	84
		9/14	M	531	14	0.09	-	30	9.0	16	2.4	47	64	16	1.7	2.9	8.5	264	112	74	280	6.8	95	81
	20	6/02	M	4.0	3.9	0.12	-	16	6.2	8.8	0.6	62	14	14	0.7	0.0	2.2	98	66	14	185	7.4	40	80
		9/14	M	87	8.8	0.27	-	7.0	4.5	7.5	1.0	21	4.8	19	0.3	0.2	1.6	64	36	19	98	6.5	240	83
	21	6/02	M	74	11	0.03	-	48	17	25	1.8	105	126	18	1.7	0.9	6.3	308	190	104	495	7.6	10	81
		9/14	M	837	12	0.12	-	25	8.6	13	1.8	55	46	16	1.7	1.4	8.8	161	98	53	245	6.8	110	83
	22	9/14	M	28	8.8	0.46	-	33	6.7	16	2.1	91	29	29	0.4	0.6	1.2	172	110	36	288	7.0	100	83
	23	9/14		-	11	0.17	-	23	7.2	12	1.9	56	37	14	1.5	1.0	5.8	143	87	41	232	6.9	100	83

**Chemical analyses for station 9, discharge data for station 8.

‡Includes 80 ppm as carbinate (CO_3).

Source: EPA (1978 a).

Table 7-7. VIOLATIONS OF SURFACE WATER QUALITY CRITERIA FOR THE PEACE RIVER.

Parameter	Class III Criteria	Violations of Criteria[1] Peace River [2]
Turbidity	50 J.T.U.	Few
Dissolved Oxygen	5 mg/1 (min.)	No
BOD	5 mg/1	No
pH	6 to 8	Few
Nitrogen-Nitrite-Nitrate	1 mg/1	Yes
Total Kjeldahl Nitrogen	1 mg/1	No
Ammonia	0.5 mg/1	Few
Phosphorus	0.1 mg/1	Yes
Fluoride	1 mg/1	Yes
Iron	0.3 mg/1	Few
Mercury	0.05 mg/1	No
Arsenic	50 μg/1	-
Cadmium	5 μg/1	-
Chromium	50 μg/1	-
Nickel	100 μg/1	-
Lead	50 μg/1	-
Total Coliforms	1,000/100 ml	Few
Fecal Coliforms	200/100 ml	-

[1] Yes = Consistent violation of criteria.
No = No violation measured.
Few = Infrequent violation of criteria.
- = Not measured.

[2] Segment 25.2BA-2.

Source: Smith and Gillespie, Engineers, Inc. 1977.

Table 7-8. WATER QUALITY PARAMETERS FOR ANALYSIS OF SAMPLES COLLECTED OCTOBER 16 AND 17, 1980 AT SELECTED SURFACE WATER MONITORING STATIONS[1].

INORGANICS

Ammonia, Nitrogen[2]
Arsenic (ug/l)
Barium (ug/l)
Beryllium (ug/l)
Bicarbonate
Cadmium (ug/l)
Calcium
Carbonate
Chloride
Chromium (VI) (ug/l)
Copper (ug/l)
Cyanide (ug/l)
Fluoride
Hydrogen Sulfide
Iron (ug/l)
Lead (ug/l)
Magnesium
Manganese (ug/l)
Mercury (ug/l)
Nickel (ug/l)
Nitrate, Nitrogen
Nitrite, Nitrogen
Phosphorus, Total
Ortho Phosphate
Potassium
Selenium (ug/l)
Silica, Total
Silver (ug/l)
Sodium
Solids, Dissolved
Solids, Suspended
Sulfate
Zinc (ug/l)

ORGANICS

Endrin (ug/l)
MBAS
G-C Scan for Total Organochlorine Pesticides
Lindane (ug/l)
Methoxychlor (ug/l)
Oil and Grease
TDC
TOC
Organic Nitrogen
Phenolics (ug/l)
Toxaphene (ug/l)
2, 4-D (ug/l)
2, 4, 5-T (ug/l)
3, 4, 5-TP Silvex (ug/l)

RADIOACTIVE

Gross Alpha (pCi/l)
Gross Beta (pCi/l)
Radium 226 (pCi/l)
Thorium 230 (ug/l)
Uranium (ug/l)

MISCELLANEOUS

Alkalinity
Color (PCU)
Oxidation Reduction Potential (ORP) (mV)
Dissolved Oxygen
Fecal Coliform Bacteria (#/100ml)
Fecal Streptococcal Bacteria (#/100ml)
Hardness (Calcium, Magnesium, and Total)
Odor (TO)
pH
Specific Conductance (umhos/cm)
Temperature (C)
Turbidity (NTU)

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[1] Stations M5, M6, and M7.
[2] All parameters to be reported in mg/l unless otherwise noted.

Table 7-9. STATISTICAL SUMMARY OF SURFACE WATER QUALITY DATA FROM SELECTED STATIONS ON THE FARMLAND INDUSTRIES, INC. MINE PROPERTY IN HARDEE COUNTY, FLORIDA; JUNE 1977 - JUNE 1978.

Parameter [1]	Peace River [3]				Troublesome Creek [4]				Hickory Creek [5]				Oak Creek [6]			
	X̄ [2]	S.D.	Min.	Max.	X̄	S.D.	Min.	Max.	X̄	S.D.	Min.	Max.	X̄	S.D.	Min.	Max.
Discharge, cfs	-	-	-	-	48	162	0.0	771	53	130	0.0	540	104	330	0.0	1390
Conductivity, umhos/cm	290	77	140	430	221	79	128	310	144	53	50	245	154	67	58	350
pH, std. units	6.4	0.6	5.4	7.4	6.6	0.6	5.5	7.5	6.3	0.7	4.4	7.8	6.2	0.6	4.8	7.0
Suspended solids	9	5	<5	22	7	3	<5	17	12	20	<5	116	19	23	<5	117
Total organic carbon	18.3	7.3	8.5	33.8	21.8	11.6	3.5	44.0	28	11	5.8	50	39.1	13.1	10.2	67.8
Dissolved oxygen	7.6	1.7	5.2	9.8	7.3	1.8	4.5	10.0	6.9	3.0	0.2	12.2	4.8	3.0	0.0	15.1
Biochemical oxygen demand (5-day)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrogen as N Nitrate/Nitrite	0.777	0.313	0.465	1.47	1.56	1.07	0.136	3.89	0.079	0.08	<0.004	0.293	0.115	0.326	<0.004	2.09
Ammonia	0.08	0.05	<0.03	0.23	0.06	0.03	<0.03	0.12	0.06	0.05	<0.03	0.22	0.08	0.08	<0.03	0.44
Organic	0.97	0.45	0.27	2.3	1.2	0.6	0.36	2.8	1.4	0.6	0.14	3.3	2.4	2.6	<0.02	14.9
Phosphate as P Ortho	2.30	0.71	1.41	3.79	0.602	0.164	0.265	0.89	0.65	0.26	0.323	1.3	0.75	0.52	0.223	3.50
Total	2.57	0.85	1.61	4.50	0.82	0.27	0.55	1.8	0.91	0.43	0.41	2.8	1.2	0.72	0.04	3.66
Dissolved silica	3.9	2.2	1.1	8.7	4.3	2.3	1.0	8.4	3.6	2.9	0.2	12.2	4.3	3.4	0.5	16.5
Fluoride	1.4	0.55	0.37	2.6	0.37	0.14	0.11	0.54	0.32	0.18	0.08	0.88	0.30	0.16	0.11	1.1
Iron	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aluminum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fecal coliform (#/100ml)	180	260	<2	1200	640	1620	15	7600	740	1390	<2	7500	750	2500	<2	17,000

[1] All units in mg/l unless otherwise noted.

[2] Abbreviations: X̄ = mean; S.D. = Standard Deviation; Min. = Minimum Value Determined; Max. = Maximum Value Determined.

[3] Stations SW-15 and SW-16 (24 samples between June 1977 to June 1978).

[4] Stations SW-11 and SW-12 (24 samples between June 1977 to June 1978).

[5] Stations SW-4, SW-9, SW-13, and SW-14 (42 samples between June 1977 to June 1978).

[6] Stations SW-2, SW-6, SW-7, and SW-8 (46 samples between June 1977 to June 1978).

Source: All data used in this analysis were as reported by P.E. LaMoreaux & Associates, Inc. (1978).

Table 7-10. STATE AND FEDERAL WATER QUALITY CRITERIA AND STANDARDS.

Parameter[1]	Florida Class III Water Standard	National Interim Primary Drinking Water Regulations	U.S. EPA Water Quality Criteria
Alkalinity, Total as $CaCO_3$	20	-	20
Aluminum	1.5	-	-
Ammonia (unionized)	0.02	-	0.02
Bacteriological (Fecal coliform)	200/100 ml	1/100 ml	200/100 ml
Color	-	-	75 (Health)
Dissolved oxygen (min.)	5.0	-	5.0
Fluoride	Marine only	1.4	-
Iron	1.0	-	0.3
Nitrate-Nitrogen	-	10	10
Oils and Grease	-	-	0 (Domestic water supply)
pH (Std. units)	6.0-8.5	-	5.0-9.0
Phosphate, Total as P	-	-	-
Turbidity	-	1.0 STU	-

[1] All units in milligrams/liter unless otherwise noted.

Source: Florida Administrative Code (Section 17-3.121); National Interim Primary Drinking Water Regulations (40 CFR 141); US EPA Quality Criteria for Water. 1976.

Table 7-11. DRAINAGE AREAS ON FARMLAND INDUSTRIES, INC. SITE AND DISCHARGE FROM PROPERTY BOUNDARY.

	Before Mining		Year 15 During Mining		After Mining	
	Area	Flow (cfs)	Area	Flow (cfs)	Area	Flow (cfs)
Troublesome	1,167	17.5	1,099	17.4	918	17.1
Hickory	2,261	6.9	1,763	6.0	2,598	6.9
Oak	4,055	15.8	3,190	14.9	3,967	15.7
Peace	250	-	250	-	250	-
TOTAL	7,733	40.2	6,302	38.3	7,733	39.7

Source: Farmland Industries, Inc., DRI June 1979.

Table 7-12. A COMPARISON OF THE WATER QUALITY OF THE SURFACE WATERS AND SLIME SUPERNATANT.

Constituents[1]	Surface Water[2]	Slime Supernatant[3]
pH, pH units	6.4	7.8
Specific Conductance, µmhos/cm	171.	523.
Total Dissolved Solids	200.	348.
Calcium	20.	57.
Magnesium	7.4	22.
Sodium	9.9	18.
Potassium	3.6	1.3
Bicarbonate	39	112.
Sulfate	19	144.
Chloride	29	17.
Iron	0.76	0.119
Silica	8.2	2.5
Fluoride	0.20	2.0
Nitrate, as N	1.2	1.06
Phosphorus, as PO_4	1.62	0.273
Radium-226, pCi/l	0.12	0.67

[1] Units are mg/l unless otherwise noted.

[2] Average of analyses from Troublesome, Hickory, and Oak Creeks (October 1979 and March 1980).

[3] Lamont, et al. 1975. Characterization Studies of Florida Phosphate Slimes.

Source: U.S. EPA. 1979. Development Document for Effluent Limitations Guidelines and Standards, Mineral Mining and Processing Industry, Point Source Category.

Table 7-13. **EFFLUENT CONCENTRATION OF SELECTED POLLUTANTS FROM PHOSPHATE ROCK PROCESSING OPERATIONS IN FLORIDA**

	Maximum Daily Average Concentration		
Constituent	Low	High	Average
Total Suspended Solids, mg/l	0.18	21.65	8.43
Phosphorus, mg/l	0.36	2.54	1.21
Fluoride, mg/l	1.19	2.42	1.79
pH, pH units	6.0	7.5	

Source: Ochsner and Blackwood. 1978.

Source Assessment: Chemical and Fertilizer Mineral Industry.